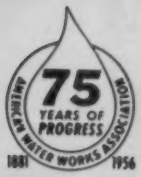
NOVEMBER 1956



Journal

VOL. 48 • NO. 11

AMERICAN WATER WORKS ASSOCIATION

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Pipe Laying	Becker, Ruggles
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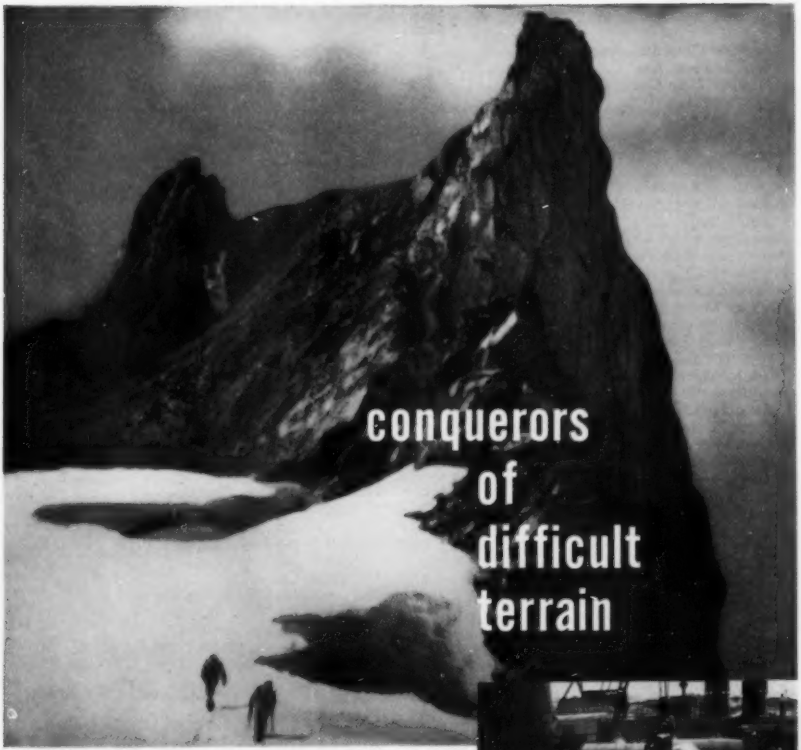
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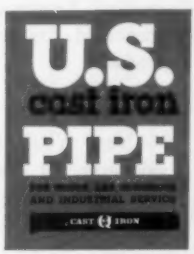
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Nov. 12–14—North Carolina Section, at Hotel Charlotte, Charlotte. Secretary, Wilbur E. Long Jr., 1615 Bickett Blvd., Raleigh.

Nov. 26–28—Rocky Mountain Section, at Broadmoor Hotel, Colorado Springs, Colo. Secretary, Jack W. Davis, Dist. Mgr., Transite Pipe Div., Johns Manville Sales, Inc., Denver, Colo.

Nov. 29–Dec. 1—Cuban Section, at Cuban Society Engineers Bldg., Havana. Secretary, Laurence H. Daniel, Pres., Laurence H. Daniel, Inc., Baratillo 9, Havana.

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Jan. 29—New York Section Midwinter Luncheon, at Park Sheraton Hotel, New York. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Feb. 6–8—Indiana Section, at Sheraton-Lincoln Hotel, Indianapolis. Secretary, Robert J. Becker, Supt. of Purif., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6.

Mar. 17–20—Southeastern Section, at Francis Marion Hotel, Charleston, S.C. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Public Health, 245 State Office Bldg., Atlanta 3, Ga.

Mar. 20–22—Illinois Section, at LaSalle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3.

Apr. 4–6—Arizona Section, at Maricopa Inn, Mesa. Secretary, H. C. Bigglestone, Luhrs Tower, Phoenix.

Apr. 5–6—Montana Section, at Rainbow Hotel, Great Falls. Secretary, Arthur W. Clarkson, Acting Chief, Water Sec., Div. of Environmental Sanitation, State Board of Health, Helena.

Apr. 10–12—Kansas Section, at Broadview Hotel, Wichita. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud St., Salina.

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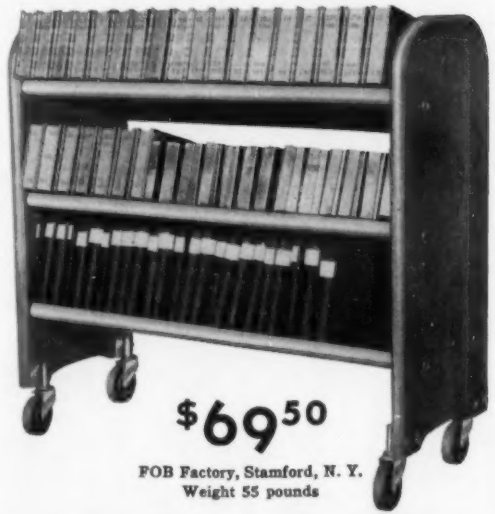
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(Continued from page 6)

Apr. 10–12—New York Section, at Mark Twain Hotel, Elmira. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Apr. 24–26—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, John E. Olsson, 408 Sharp Bldg., Lincoln.

May 2–4—Pacific Northwest Section, at Winthrop Hotel, Tacoma, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., Rm. 306, City Hall, Spokane, Wash.

Jun. 12–14—Pennsylvania Section, at Bedford Springs Hotel, Bedford Springs. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Jun. 16–18—Canadian Section, at Royal Alexandra Hotel, Winnipeg, Man. Secretary, A. E. Berry, Director, San. Eng. Div., Ontario Dept. of Health, 72 Grenville St., Toronto, Ont.

Sep. 11–13—New York Section, at Whiteface Inn, Lake Placid. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Sep. 16–18—Wisconsin Section, at Hotel Schroeder, Milwaukee. Secretary, Harry Breimeister, Chief Utility Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 18–20—Ohio Section, at Netherland Plaza Hotel, Cincinnati. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sep. 23–25—Kentucky-Tennessee Section, at Brown Hotel, Louisville, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 25–27—Michigan Section, at Leland Hotel, Detroit. Secretary, T. L. Vander Velde, Chief, Sec. of Water Supply, State Dept. of Health, Lansing 4.

OTHER ORGANIZATIONS

Nov. 12–16—American Public Health Assn., Atlantic City, N.J.

Nov. 14–16—Water Works Management Short Course, Univ. of Illinois, Allerton Park, Ill.

Nov. 27–30—National Chemical Exposition, sponsored by American Chemical Society, at Public Auditorium, Cleveland, Ohio.

Nov. 28–30—International Ozone Conference, at Sheraton Hotel, Chicago, Ill.

1957

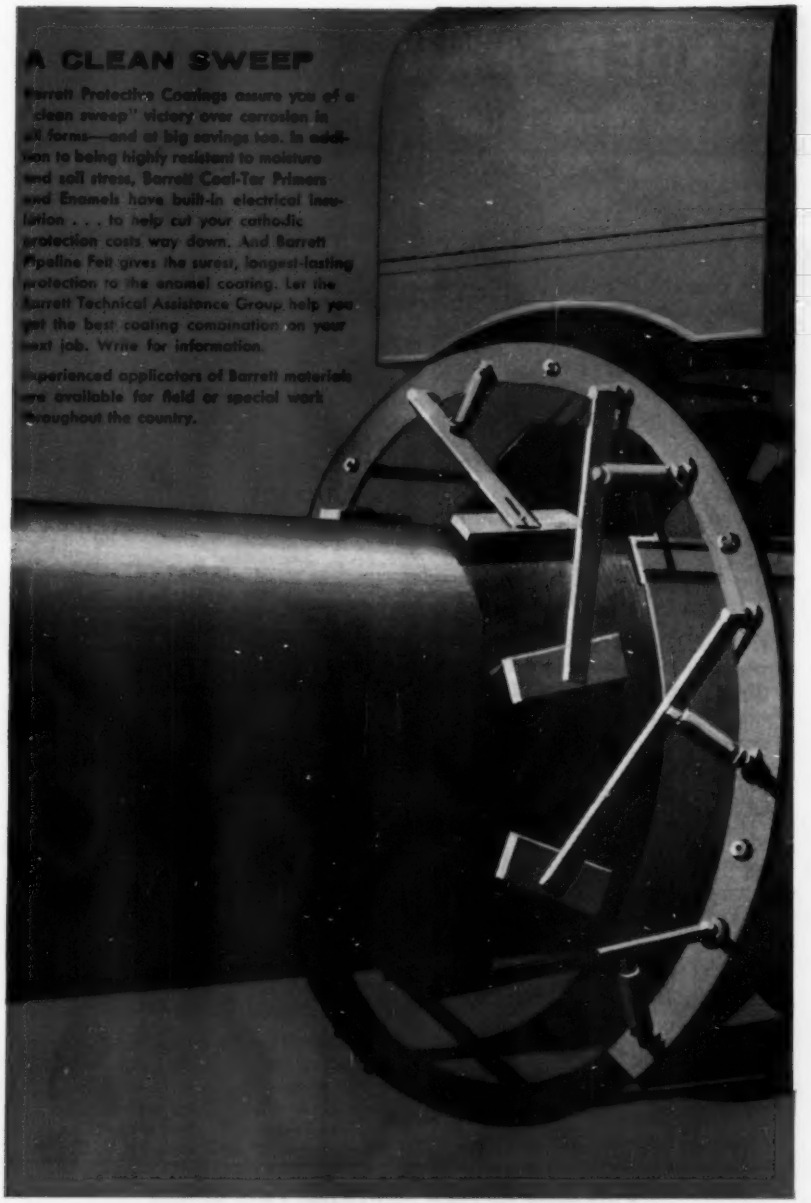
Feb. 3–5—Annual Midwinter Conference, Public Utility Buyers' Group, National Assn. of Purchasing Agents, at Brown Hotel, Louisville, Ky. Chairman, L. G. Wiseley, Michigan Consolidated Gas Co., 415 Clifford St., Detroit 26, Mich.

Feb. 18–22—American Society of Civil Engineers, Jackson, Mich.

Mar. 11–15—2nd EJC Nuclear Engineering Congress & Atomic Exposition, at Convention Hall, Philadelphia, Pa.

Mar. 25–29—Western Metals Congress & Exhibition, at Ambassador Hotel and Pan-Pacific Auditorium, Los Angeles, Calif. Managing Director, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

Jun. 16–21—American Society for Testing Materials, Atlantic City, N. J.



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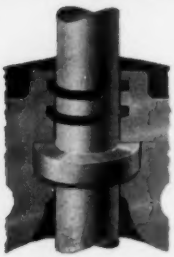
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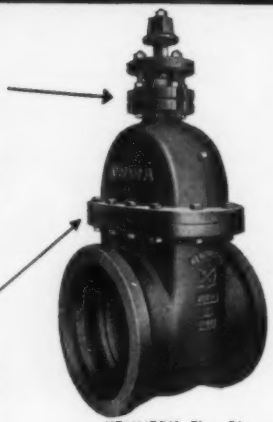
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Fig. 571


Fig. 561


Fig. 566


Fig. 566G


Fig. 566FTR

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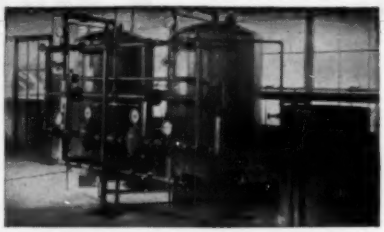
Roberts Filter *means...*

MUNICIPAL WATER PURIFICATION



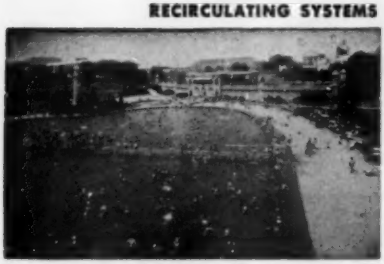
The combined capacity of Roberts-equipped filtration plants is well over 5 billion gallons (5,000,000,000) per day. Regardless of the size of the plant or the nature of the filtration problem, Roberts Filter can be depended upon for equipment that is reliable in years of service.

INDUSTRIAL WATER RECTIFICATION



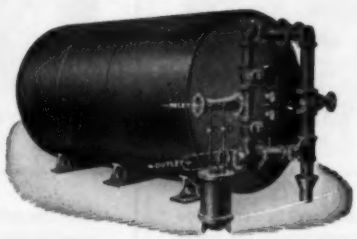
Water treatment has long been a specialty of Roberts Filter. Zeolite water softeners are guaranteed to meet all requirements for which recommended, and are available in a wide range of capacities. Roberts water conditioning equipment is widely used to control precisely the desired chemical content of water for industrial use.

SWIMMING POOL RECIRCULATING SYSTEMS



The combination of thoroughly clarified water and efficient recirculation are features for which Roberts pools are famous. Systems for both outdoor and indoor pools are designed and installed by men long experienced in the conditions peculiar to a successful swimming pool installation.

PRESSURE FILTERS



Closed pressure filters have wide usage where gravity filters are not justified. Roberts vertical filters are available in standard types from 12" to 96" diameter; horizontal pressure filters are all 8'0" in diameter and in varying lengths from 10'0" to 25'0".

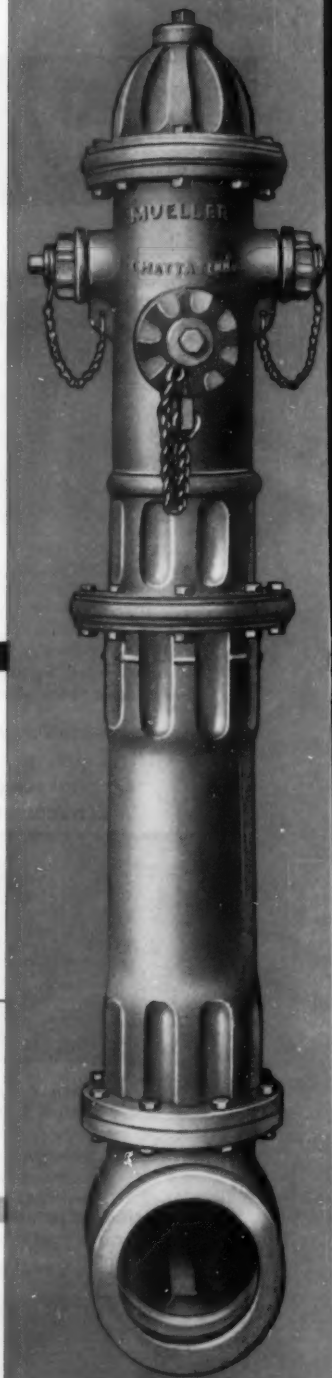
When you think of good water—think of Roberts Filter

MECHANICAL EQUIPMENT BY ROBERTS FILTER MFG. CO. DARBY, PENNA.

Roberts Filter

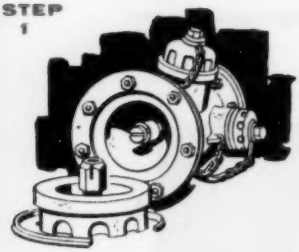
Manufacturing Company • Darby, Penna.

Always Ready



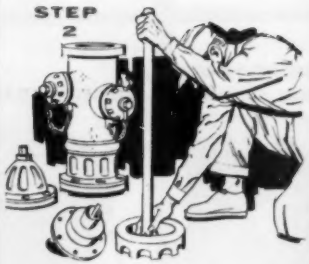
FOLLOW THESE SIMPLE STEPS

STEP 1



Remove broken safety flange from upper barrel section of hydrant. Remove damaged stem coupling and sleeve. Remove bonnet assembly, stuffing box and stem from upper barrel. (NOTE: Before sliding stem out of stuffing box, slip A-24099 brass sleeve over threads to prevent "O" ring damage.)

STEP 2



Screw new safety stem coupling down against shoulder on lower stem. Slip safety sleeve over lower end of upper stem section. Screw upper stem into safety stem coupling until it bottoms against lower stem.

Contact your Mueller Representative or write direct for complete details.

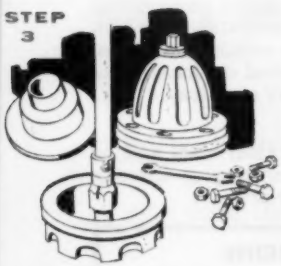
MUELLER

improved fire hydrant

Designed to withstand the most adverse weather conditions, the Mueller AWWA Improved Fire Hydrant is ready for instant use for emergencies.
Large bronze weather cap prevents freezing of operating nut.
Dry top design keeps water away from threads and bearing surfaces.
"O" ring stem seals provide perfect watertight seal and hold oil in reservoir, keeping threads lubricated. Safety stem coupling and flange provide simple, fast repair in case of traffic damage.
Above ground maintenance makes it a simple matter to keep the Mueller Improved Fire Hydrant in an "always ready" condition.

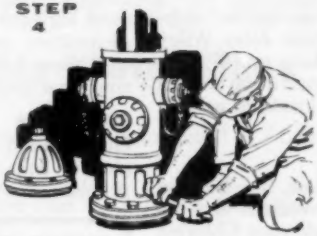
FOR REPAIR AFTER TRAFFIC DAMAGE

STEP 3



Align slot in safety stem coupling with tongue and groove in stems. Screw coupling upward until tongue and groove of stems lock firmly together. Drop safety sleeve down over upper end of coupling and tighten setscrew in sleeve.

STEP 4



Install flange gasket on lower barrel – position upper barrel making sure gasket remains centered. Bolt the two halves of the safety flange in place with circular groove facing upward. Make sure safety flange fits lower barrel snugly.

STEP 5

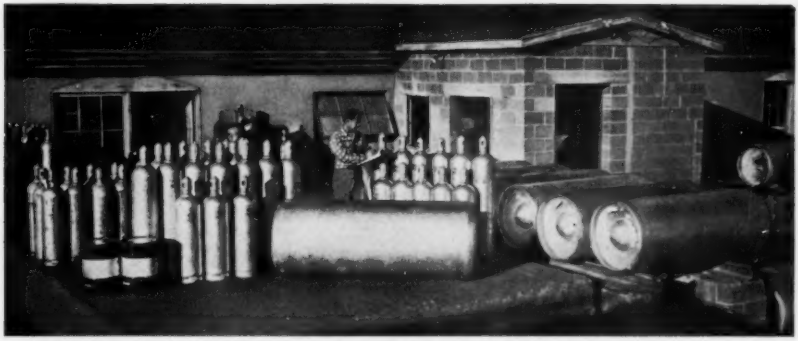


Slide stuffing box over brass sleeve on stem threads. Position stuffing box plate and bolt to barrel. Remove brass sleeve. Fill oil reservoir and replace bonnet. Turn operating nut clockwise to engage stem. Position filler plug over oil reservoir and bolt bonnet to barrel. Repair is now complete.

MUELLER CO.

Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS



AT EACH of the six Jones Company plants, Chlorine is received in tank cars, repacked in smaller containers selected to meet the customer's needs.

Save storage space and shipping time on your next CHLORINE purchase!

Get fast delivery on *many* chlorine products in whatever container best fits your needs.

Stop the cost and nuisance of storing huge amounts of Chlorine. Buy only what you need—whether it's several carloads, just part of one tank car, or as little as 16 lbs.!

You can get less-than-carload shipments of Chlorine from John Wiley Jones. And you get them quickly, because Jones has six distribution centers spotted in important locations around the country.

Eliminates searching

You save searching time, too, because you have a *single* convenient and dependable source for *all* your Chlorine products: liquid Chlorine. Calcium Hypochlorite, and Sodium Hypochlorite.

Cylinders, tins, drums, carboys, and ton-tanks—Jones delivers in any type of container you require. This gives you complete protection against sudden emergency needs for Chlorine.

Top quality

Jones Chlorine is quality controlled to meet high government standards. Municipalities, public utilities and industrial users have relied on Jones Chlorine for a quarter of a century.

Dependable

Our trained technical staff will be glad to help you solve *your* Chlorine problem. Write for prices.



LIQUID CHLORINE
In 16-, 105-, 150-lb. cylinders and 1-ton tanks.

CALCIUM HYPOCHLORITE
(70% available Chlorine) In 3¼- and 5-lb. tins, 100-lb. drums.

SODIUM HYPOCHLORITE
In gallons, carboys. Tankwagon deliveries in 1000-3000 gal. lots.

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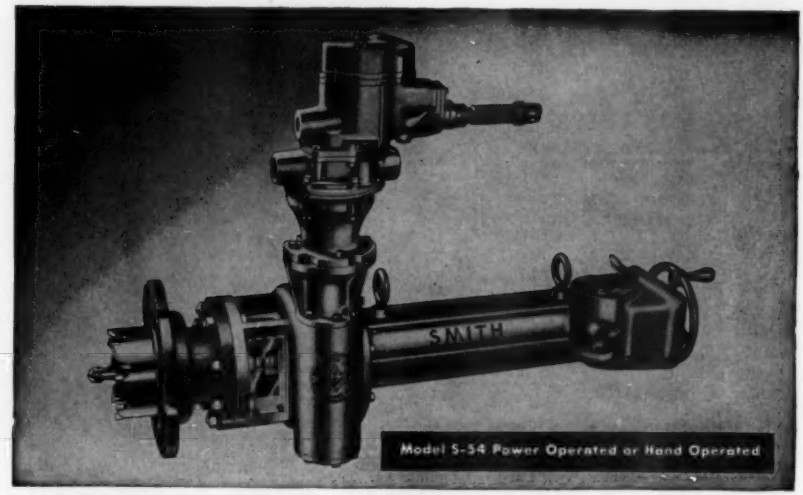


Here's why *CONCRETE PIPE* is "Tops" for Water Lines

- It can be designed for all pressures used in American waterworks.
- Its dense structure and watertight joints end leakage worries.
- It maintains high hydraulic efficiency indefinitely. Concrete pipe does not tuberculate.
- It minimizes taste, odor and dirty water difficulties.
- It has ample strength to sustain heavy overburdens and to withstand severe climatic and soil conditions.

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A national organization to improve and extend the uses of portland cement and concrete through scientific research and engineering field work

SMITH TAPPING MACHINES FOR TAPS 2″ THRU 12″ INCLUSIVE



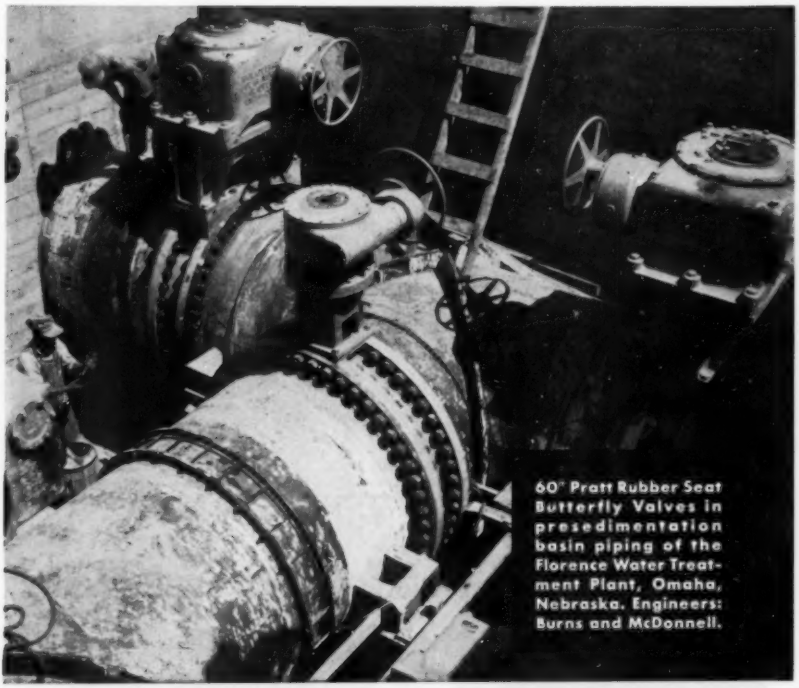
The NEW Smith S-54 Tapping Machine is the most modern, efficient and economical machine available. The Machine is used with Tapping Sleeves, Hat Flanges, Saddles and Tapping Valves to make 2″ through 12″ connections under pressure to Cast Iron, Cement-Asbestos, Steel and Reinforced Concrete Pressure pipe. Features: 1. Positive automatic feed insures correct drilling and tapping rate. 2. Travel is automatically terminated when tap is completed—cutter and shaft cannot overtravel. 3. Telescopic shaft reduces overall length. 4. Mechanism is housed in heat treated Aluminum Case filled with lubricant. 5. Stuffing Box and Packing Gland is accessible without disassembling machine. Line pressure cannot enter machine case. 6. Extra large diameter telescopic shaft add strength and rigidity. Timken radial—thrust bearings maintain alignment, reduce friction and wear. 7. Worm gearing operates in lubricant, torque is reduced to the minimum. 8. Cutters have replaceable Flat and Semi-V alternate teeth of High Speed Steel or Tungsten Carbide. 9. Flexibility: Hand Operated Machines can be converted to Power Operation by interchanging worm gearing. Bulletin T54 sent on request.

53

FIRE HYDRANTS SINCE 1906 STEEL

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY



60" Pratt Rubber Seat Butterfly Valves in presedimentation basin piping of the Florence Water Treatment Plant, Omaha, Nebraska. Engineers: Burns and McDonnell.

OMAHA ... Butterfly Valves are key to compact piping

This ultra-compact arrangement of three 60 inch valves could only be made with Butterfly Valves. The illustration shows the narrow face-to-face dimensions (only 15") and the compactness of the valve-operator assemblies. What you can't see is equally important! The rugged internal construction—the rubber seat that is never under severe pressure from the valve disc, only partially displaced during closure ... features that mean years of easy operation without maintenance problems or costs.

Pratt originated the Rubber Seat Butterfly Valve and has installed more of them than any other manufacturer.

For valve design with a 50 year reputation for practical imagination, see Henry Pratt.

NEW! Latest, most accurate pressure drop and flow data, conversion tables, discussion of butterfly valve theory and application plus other technical information. Write for Manual B-2C.

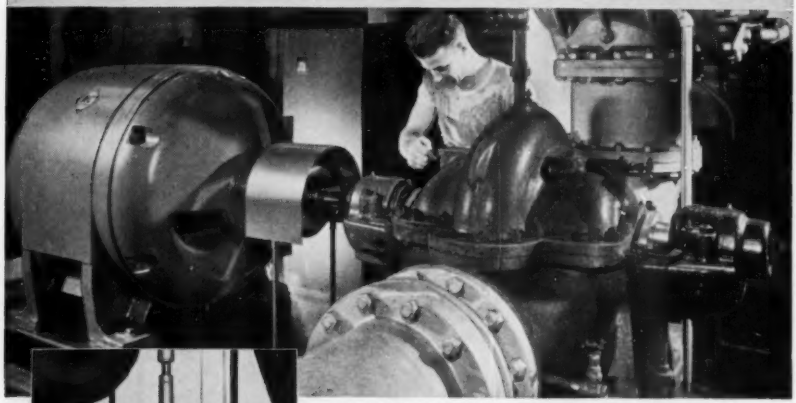


HENRY PRATT

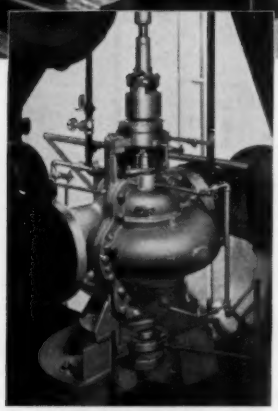
RUBBER SEAT Butterfly Valves

Henry Pratt Company, 2222 S. Halsted St., Chicago 8, Ill. Representatives in principal cities

Allis-Chalmers PUMPS Solve a Water Works Problem



Newly installed Allis-Chalmers horizontal high-lift, 5215-gpm, 220-ft head pump, driven by 350-hp, 1170-rpm Allis-Chalmers motor, replaces old Allis-Chalmers pump-motor combination.



This new Allis-Chalmers vertical pump, rated 5215 gpm at 55-ft head and driven by a 100-hp, 1170-rpm induction motor, pumps raw water out of Lake Michigan into the filter beds.

Waukegan Increases Capacity, Modernizes Plant . . . Again Specifies Allis-Chalmers

Although pumps, motors, control and switchgear, installed in 1928, were still giving dependable, economical service, need for increased capacity indicated replacement of some equipment at the Waukegan (Ill.) Water Works.

The first step in modernizing the plant was to replace two of the original 16 pumping units, one vertical and one horizontal. This included new Allis-Chalmers pumps with increased capacity, new motors, and new control.

You get MORE than a Pump . . .
When You Specify Allis-Chalmers

You can take advantage of Allis-Chalmers wide experience in supplying pumps to all industries. You are assured of modern design, heavy-duty construction and correct application aid — all resulting in added years of dependable, economical, day-after-day pumping service.

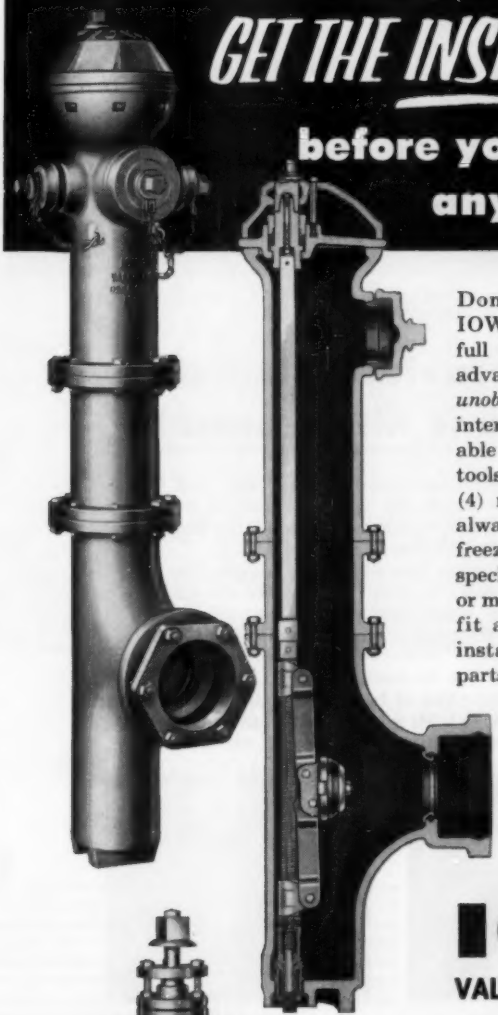
Allis-Chalmers is the only company that can offer you "One-Source" responsibility, with a complete unit — pump, motor and control — all built to work together. For MORE information, call your local A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-5133

A-C ALLIS-CHALMERS

GET THE INSIDE STORY

before you specify any hydrant!

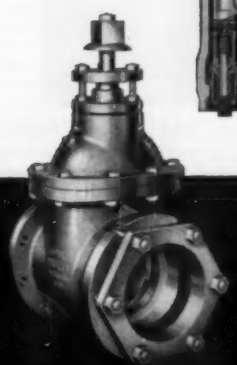


Don't buy blindly! Only in IOWA hydrants do you get full measure of such practical advantages as: (1) absolutely *unobstructed* waterway; (2) all internal working parts removable through top; (3) no special tools needed for maintenance; (4) no binding or distortion, always easily opened; (5) no freezing; (6) meet all A.W.W.A. specifications; (7) bell, flange or mechanical joint connections fit any existing or planned installation; (8) replacement parts always available.

that's why farsighted city officials choose

IOWA

VALVES AND HYDRANTS



for COMPLETE details, address:

IOWA

VALVE COMPANY

A Subsidiary of James B. Clow & Sons, Inc.

Oskaloosa, Iowa

At St. Petersburg's new Cosme filter plant



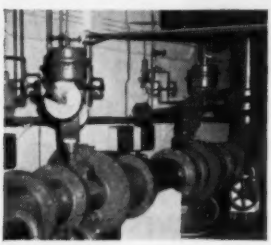
Cosme Plant: Filter capacity 24 MGD • Consulting Engineers: Greeley and Hansen
Mechanical Contractor: Bass Construction Co.

Simplex provides Centralized automatic filter control!

The St. Petersburg, Florida, water system has just been expanded. In the Cosme plant, the latest addition—a new, master pneumatic control system provides the dependable accuracy that assures *maximum filter efficiency.*

Backbone of the system are tried and proven Simplex "S" Controllers for each filter to keep rate-of-flow constant despite changes in head. From these direct-acting controllers, new Simplex Laminair Converters transmit pneumatic signals instantly. So at the new, sensitive bellows-type Receiving Instruments, there's no hunting, no lag, no inaccuracies!

Results: Rate of flow, loss of head and water levels are indicated and recorded, with total plant flow summated, *at one central table* that operates all filters at optimum rates.



Filter gallery: Diaphragm pots for Master Pneumatic System are just above counterbalanced arms of the Simplex Controllers.

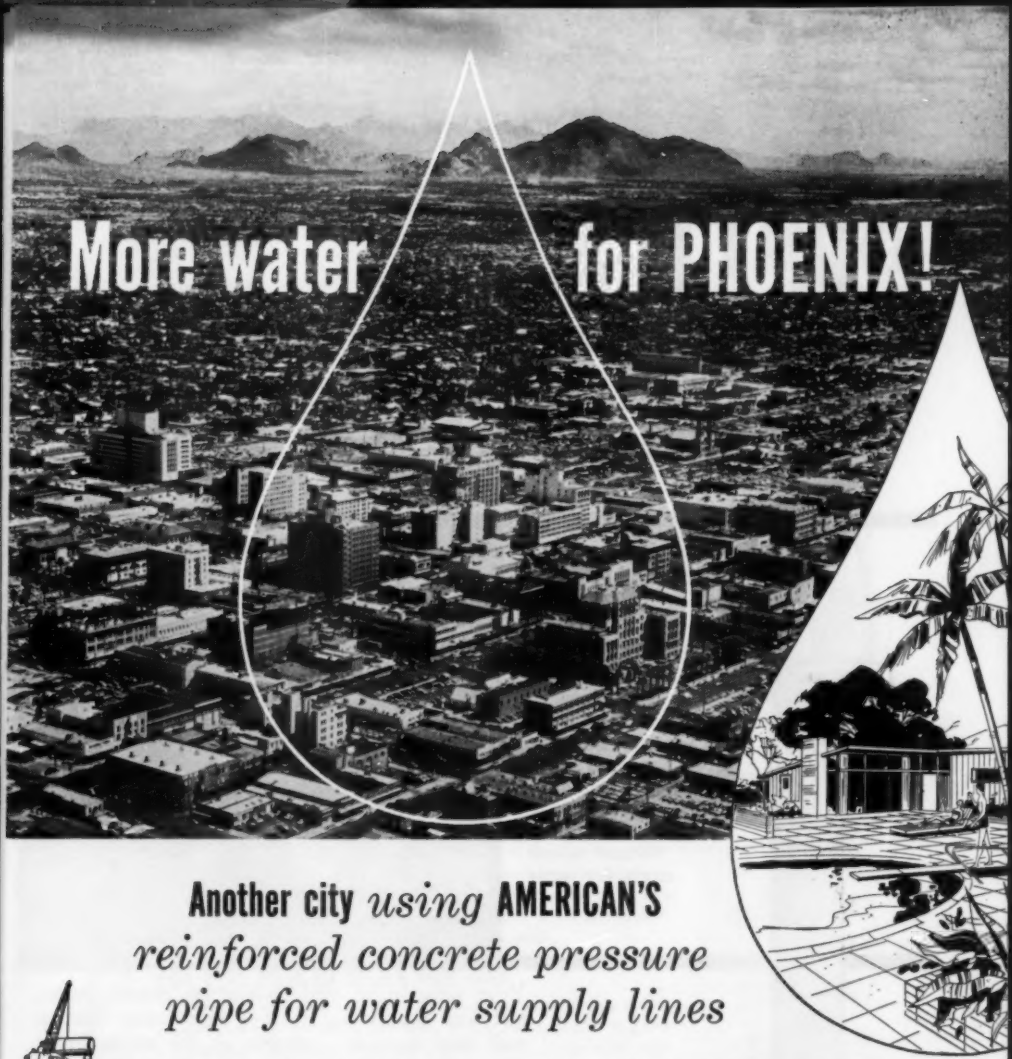


At this one table, Simplex pneumatic receivers give centralized measurement of summated plant output and centralized control of flow.

FREE TECHNICAL INFORMATION!
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7 E. Orange St., Lancaster, Pa.

Accurate instruments and controls for over 50 years

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VALVE AND METER COMPANY



Another city *using* AMERICAN'S *reinforced concrete pressure pipe for water supply lines*

The City of Phoenix, Arizona is another of the rapidly growing cities of the Southwest which have faced tremendous water supply problems and have met them successfully. The population of Greater Phoenix has increased almost 50 per cent in the past five years. An annexation program is currently increasing the rapid expansion of the City of Phoenix which is one of the fastest growing cities in the nation.

During 1953 American Pipe and Construction Company, through Fisher Contracting Company, general contractors, supplied Phoenix with more than 37,000 feet of large diameter concrete pressure pipe for a line which increased the Phoenix primary feeder capacity from 100,000,000 MGD to 210,000,000 MGD. The pipe furnished was pre-stressed concrete cylinder pipe designed for the operating pressures established under specifications prepared by Yost & Gardner, consulting engineers for the City of Phoenix.

American has helped to meet the special problems faced by Phoenix water officials by designing and supplying reinforced concrete pressure pipe especially for conditions in the Phoenix area.

A recent merger with Hooper Concrete Pipe Company in Phoenix gives American another permanent plant from which to serve the cities of the Southwest.

American Pipe and Construction Company makes available 49 years of experience and extensive production facilities to help solve any water supply problem. There is a type of American pipe to meet any requirement. Write or phone for complete information.

American PIPE AND CONSTRUCTION CO.

Concrete pipe for main water supply lines, storm and sanitary sewers, subaqueous lines

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Sparton

well field control systems

SAVE SUPERVISORY HOURS • MINIMIZE POWER FAILURE DOWNTIME • ASSURE EMERGENCY WATER • ENABLE ACCURATE PROGRAMMING . . . with FULL FLEXIBILITY for expansion.



Sparton multi-channel scanning system ties one to 25 wells to treatment plant, eliminates restart delays, minimizes downtime due to storm induced failures, assures emergency water.



Your solution to well shut-down, restart delays, and lost supervisory time — dependable Sparton well field controls — proven on the storm-driven plains, in river floodlands, under heavy municipal load. For reliable centralized supervision, these systems employ trouble-free d.c. telegraphy and/or tone techniques over conventional transmission or telephone line. They're tailored to your exact needs, yet offer installation economies through use of standard, pre-engineered control modules.

Sparton

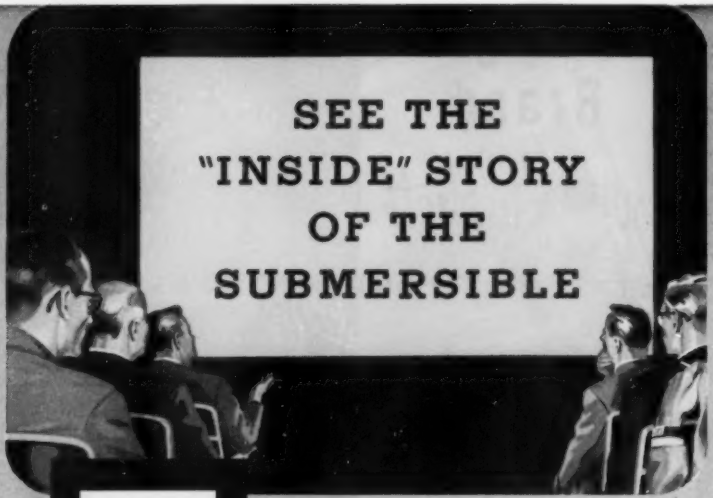
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SEE THE "INSIDE" STORY OF THE SUBMERSIBLE



BJ

This new Byron Jackson film shows you the basic principles and operation of the Submersible pump in a technically accurate and extremely entertaining full-color movie.

"The Submersible Story" is a factual account of the modern pumping unit that operates with both motor and pump underground—out of sight and out of sound. Extensive animation shows the construction, operation and working principles of key Submersible parts, including the mechanical and mercury seals.



PUT THIS FILM TO WORK FOR YOU

This film has many uses. It gives maintenance personnel an understanding of the operation and care of the Submersible. It gives engineering and technical people a better grasp of the basic engineering principles involved. It gives non-technical people the interesting history and application of this modern pumping method.

Byron Jackson—manufacturer of the BJ Submersible—extends an invitation to you to see this new film and to arrange showings for interested groups and organizations. There's no obligation. Write Roger Barron, Submersible Products Manager, Byron Jackson Pumps, P. O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

FILM HIGHLIGHTS:

- The First Submersible Motor
- Oil Lubrication versus Water Lubrication
- Principle of Mercury Seal and Mechanical Seal
- Installation of the Submersible
- The Submersible's Many Uses
- Two Approaches to Municipal Pumping Needs

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Triangle Brand Copper Sulphate

HELPS SOLVE YOUR WATER PROBLEMS

Triangle Brand Copper Sulphate economically controls microscopic organisms in water supply systems. These organisms can be eliminated by treatment of copper sulphate to the surface. Triangle Brand Copper Sulphate is made in large and small crystals for the water treatment field.

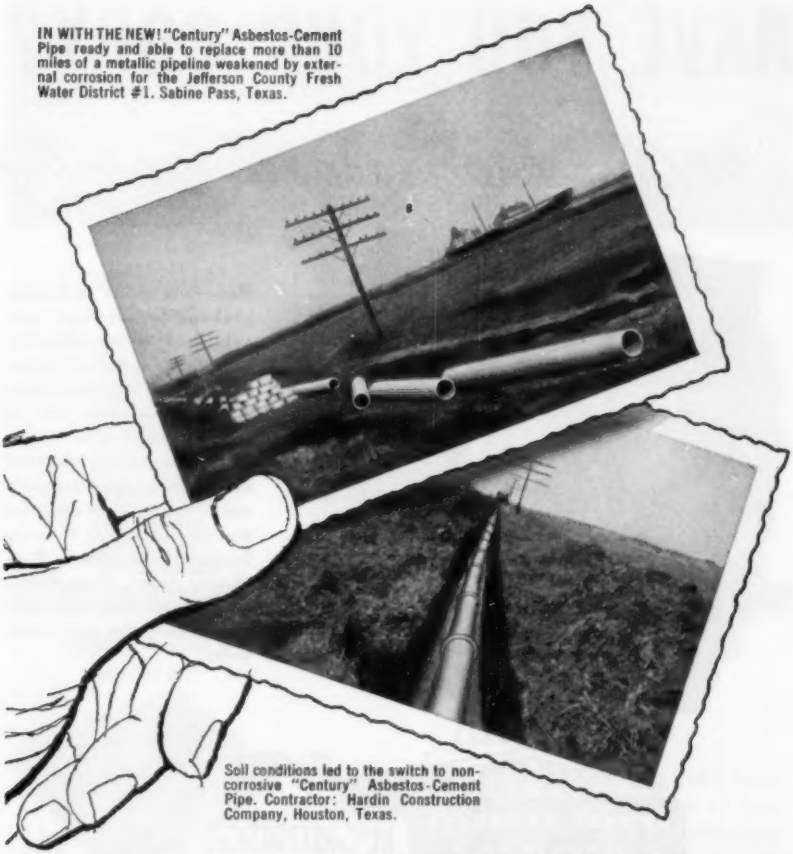
Roots and fungus growths in sewage systems are controlled with copper sulphate when added to sewage water without affecting surface trees.

Booklets covering the subject of control of microscopic organisms and root and fungus control will be sent upon request.

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IN WITH THE NEW! "Century" Asbestos-Cement Pipe ready and able to replace more than 10 miles of a metallic pipeline weakened by external corrosion for the Jefferson County Fresh Water District #1. Sabine Pass, Texas.

Soil conditions led to the switch to non-corrosive "Century" Asbestos-Cement Pipe. Contractor: Hardin Construction Company, Houston, Texas.

non-corroding!

K&M "Century"® ASBESTOS-CEMENT PRESSURE PIPE

Throughout the country more and more communities are relying on water mains of K&M Asbestos-Cement Pipe . . . made of asbestos fiber and portland cement. It resists corrosion, is non-electrolytic, two of the many advantages which make for durability.

Pumping costs low and stable! There is no clogging to reduce flow and increase pumping costs with K&M Asbestos-Cement Pipe. It is non-metallic . . . non-tuberculating. Its bore remains smooth and clean.

Lower in initial cost! K&M Asbestos-Cement Pipe is light in weight —easily and inexpensively transported, stored and handled.

Write for complete details.

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K&M first in asbestos

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Manufacturers of: Underwriters Approved fire hydrants, hose valves and siamese connections. Fire protection hose goods; industrial, Navy and maritime bronze valves and fittings; plumbing and hardware brass specialties; bronze plaques, letters and name plates; crematory and cemetery bronze products.

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WHEN THE FIRST HYDRO-TITE JOINTS WERE BEING POURED -



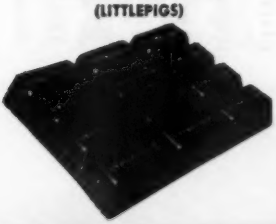
HYDRO-TITE (POWDER)



HYDRO-TITE (POWDER)

For over 40 years HYDRO-TITE has been faithfully serving water works men everywhere. Self-caulking, self-sealing, easy-to-use. Costs about 1/5 as much as lead joints. Packed in 100 lb. moisture-proof bags.

HYDRO-TITE (LITTLEPIGS)



HYDRO-TITE (LITTLEPIGS)

The same dependable compound in solid form —packed in 50 lb. cartons—2 litters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX (REELS)



FIBREX (REELS)

The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.



HYDRO-TITE

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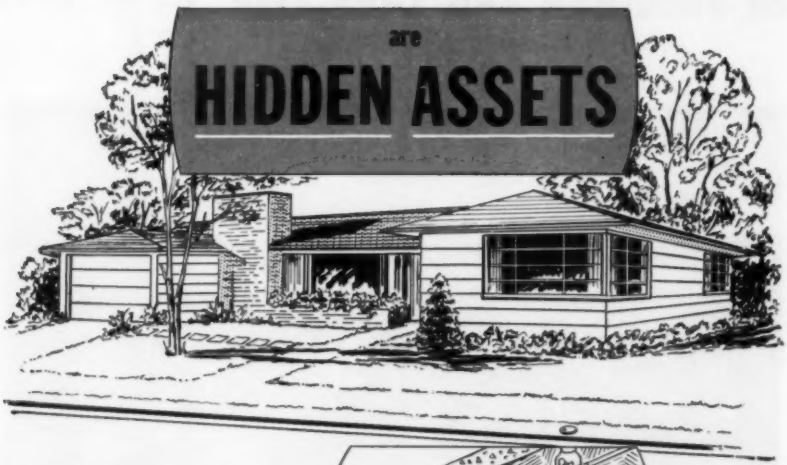
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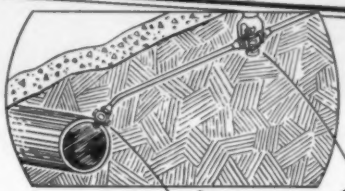
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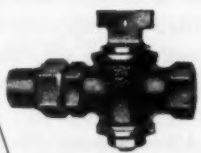
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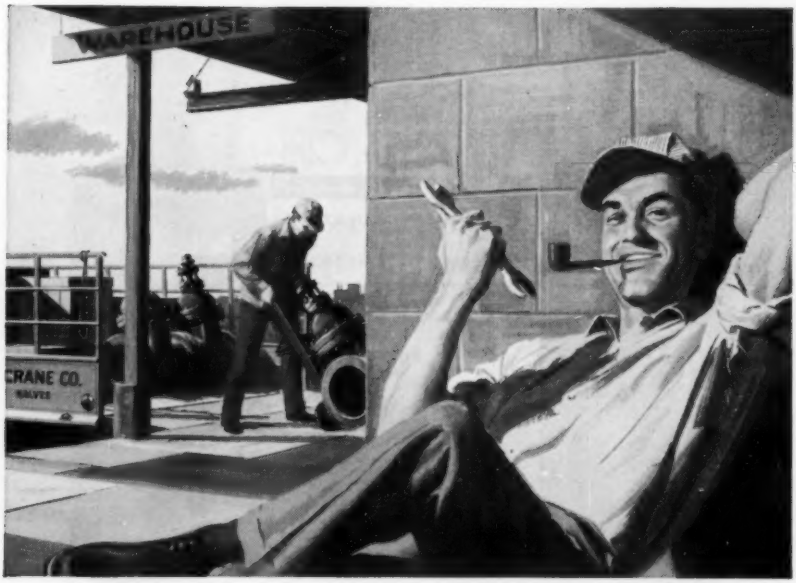
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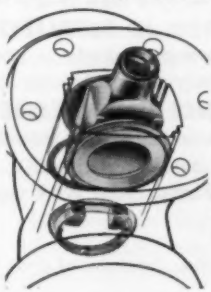
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Trends in Residential Water Use

Ross Hanson and Herbert E. Hudson Jr.

A paper presented on May 10, 1956, at the Diamond Jubilee Conference, St. Louis, Mo., by Ross Hanson, Assoc. Engr., State Water Survey Div., Urbana, Ill., and Herbert E. Hudson Jr., Cons. Engr., Hazen & Sawyer, Engrs., Detroit, Mich., and formerly Head, Eng. Subdiv., State Water Survey Div., Urbana, Ill.

IT is common practice to express per capita water consumption for a given community as the quotient of the total pumpage and the census population. This method assumes that all of the water pumped gets to the users, and assumes further that all persons counted in the census are served with water from the system. The resulting figure may at times be completely misleading; as, for example, when the population served differs from the census population, or when total water used differs from the total pumpage.

It is the thesis of this article that water use can better be established on the basis of sales per water service connection—that is, that per capita consumption can best be expressed as the amount of water sold to residential users, divided by the product of the number of services and the number of persons per service connection.

Data gathered by the Illinois State Water Survey in 1954 indicated that declines in water consumption per service connection were taking place in certain Illinois communities over the period 1920–53. Compared with reports from other parts of the country, this indication seemed so unreasonable that further study was initiated. The study showed that changes in per capita consumption had been masked by two factors: [1] the declining number of persons per household, and [2] the increasing proportion of the community population served. The study also indicated that several other factors heretofore omitted from consideration play a role in the estimation of water use in homes served by public water supplies.

For the 1954 study, information was gathered from a number of communities in Illinois that were faced with

real or potential water shortages, presumably as a result of the drought. A preliminary report (*1*) on this study concluded, in part, as follows:

> It is noted . . . that a number of the communities, for which pumpage increases were either small or negative, experienced population declines during the period of study. In other instances, the lack of pumpage increase was known to be linked to the inadequacy of the water source development, so that it was recognized in these communities that frugal use of water was essential to prevent a general shortage.
>
> In some instances part of the increase can be attributed to leakage and wasteful use, but this is believed to be a relatively small proportion. Most of the increase seems to be due to two factors: [1] increase in number of service connections, and [2] increases in per capita and . . . industrial use. In many of the communities studied, these increases have not yet fully materialized, and may be expected to develop in future years.

The data from the 1954 study were incomplete in some respects. Additional information was sought, therefore, from a number of Illinois communities for which fairly adequate records were available. These communities are distributed over the state, as shown in Fig. 1, which also indicates the type of supply source used. Five of the communities relied on ground water, and seven relied on surface water.

There may be some bias in the sampling, as the water supply administrations of all the communities involved had maintained reasonably detailed records in recent years, indicating that they were probably better operated than the general average. Data for the years 1940–55 were available for most communities, and earlier records were available for some.

The information sought from each community included the total pumpage, the number of services, and the sales of water in each of the following categories: [1] total, [2] residential, [3] commercial, [4] industrial. In addition, information was sought on sales to water haulers, and on "free" water



Fig. 1. Distribution of Illinois Towns Studied

Square black markers indicate surface water supply, round black markers, ground water supply.

to municipal offices, parks, playgrounds, drinking fountains, and similar uses. Little information was obtained on sprinkling and air-conditioning loads.

All of the communities metered water sales to almost all accounts, so

that a breakdown of sales into the several categories could be obtained. The available data also made possible the determination of gallons per day per service in each of the various categories.

In addition, master metering of the entire pumpage was considered an important item, as it made possible the determination of "unaccounted-for" water. Unfortunately, however, master metering was not always available. In some cases, therefore, estimates of unaccounted-for water have been used.

For each community, the US Bureau of the Census population statistics were available, together with census data for 1940 and 1950 on the number of occupied dwelling units. These figures could be compared with total residential services.

Wherever a substantial proportion (more than 2 per cent) of the service connections were outside the corporate limits of the community, a breakdown of the number of service connections was obtained. As a rule, these additional services were in unincorporated areas for which population data were available. In such areas, the total number of services shown for the water system includes the services outside the community, and the population, total pumpage, and sales figures also include the number of persons and the quantities of water involved outside the corporate limits. In a number of areas this was an important factor, as several of the systems furnished water to subdivisions beyond the corporate limits. Others furnished water to nearby municipalities of considerable size.

Data from Bureau of the Census publications proved very useful. Whereas, prior to the 1950 census, dwelling units in unincorporated areas outside corporate limits had been classified as "rural" (*2*), in the 1950 census, dwellings in urban fringe areas were classified as "urban." The census reports provided information on the number of households, the number of persons per household (size of family), trends in population, the relationship between urban and rural populations, the proportion of the urban population served by public water supplies, and the number of dwelling units in the community that had running water inside the house.

Number of Households

One of the biggest problems facing a public water supply system is furnishing service to new accounts. The decennial census reports and certain special Bureau of the Census reports on population (*3, 4*) reveal that the number of private households in the United States increased from 1940 to 1950 much more rapidly than the population, and the average size of family consequently showed a substantial decline (*5, 6*).

The decline in family size occurred despite the high birth rate during the 10-year period. The effects of a high birth rate were more than offset by the effects of the high marriage rate and other factors that tended to increase the number of households (*6*). In 1950, about 5.6 per cent of married couples had not established their own households but were sharing the living quarters of other persons or were living in hotels, rooming houses, or other quasi households. Corresponding percentages for earlier years were 6.8 per cent in 1940 and 6.1 per cent in 1930 (*6*). Taking into account low birth rates during the depression years of the 1930's, the increasing average lifespan, and the growing tendency for older persons to maintain their own households into old age, the Bureau of the Census (*7*) observed that "the indicated trend in household and fam-

ily formation is generally downward for the 1950's." Extraordinary increases in the establishment of new households were observed during the postwar years 1947–50, and those increases brought on many of today's water service problems. Subsequent increases were smaller, and are not expected to be as high in the near future.

The census projections indicate that the number of households will rise from

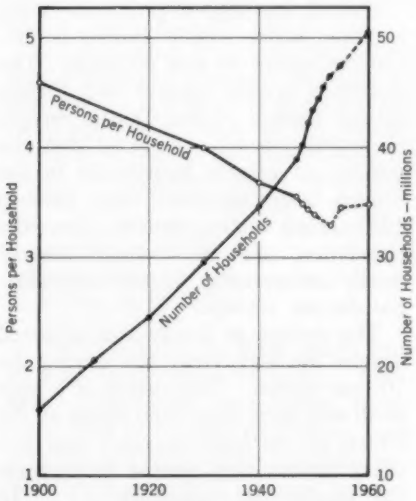


Fig. 2. Number of Households and Family Size, United States, 1900–1960

45,500,000 in April 1952 to 47,700,000 in July 1955, and to 50,800,000 in July 1960 (*7*). More recent census studies give additional information on rates of establishment of households (*8, 9*).

Size of Households

The very rapid increase in household formation in the late 1940's leads to curiosity about the size of family units. Beginning with the 1940 decennial census, the Bureau of the Census reports provided information on the number of persons per household. The data given seem to compare reasonably well with the data available in earlier censuses on persons per family (*5*).

Figure 2 compares the number of households and the number of persons per household from 1900 to 1960, for the entire nation, as enumerated and projected by the Bureau of the Census. The data show a very marked decline in the number of persons per household, from 1900 to 1953. The greatest rates of change are shown to have occurred in the period after 1946. It will be noted that the number of persons per household in the United States as a whole declined 30 per cent from 1900 to 1953. In the corresponding period, the decline in Illinois was 35 per cent.

Data on persons per household through 1950 were also available for the several Illinois communities which are the basis of this study. The curves for these communities have been prepared from data available in the decennial census reports from 1920 to 1950, and the subsequent projections were drawn from predictions in intercensal reports prepared by the Bureau of the Census for the state of Illinois. Fig. 3 shows the graphs for three of the communities. They reveal trends similar to the national and state trends. Studies of other communities within the state reveal even more marked variation.

Proportion of Population Served

Prior to World War II, many water systems in Illinois were installed on a basis of serving only part of the population within the incorporated limits of the municipality. In some systems, the proportion served ranged from 10 to 25 per cent of the entire population.

This has increased rapidly in many small communities, but in some this development is quite incomplete.

In 1940, of all the urban dwelling units in the United States, 96 per cent had running water inside the home; in 1950, the figure was 97.2 per cent. Most of this change was caused by increases in extension of service in communities of less than 10,000 persons. This phenomenon is obviously no national problem, but it has caused grave difficulties for many small communities.

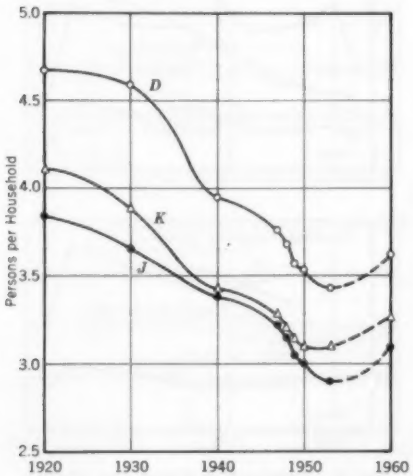


Fig. 3. Persons Per Household, Three Illinois Towns, 1920–1960

For rural homes, the situation is different. In 1940, 20.7 per cent of rural homes in Illinois, and 22.7 per cent of those in the entire United States, had piped, running water. In 1950, 51.2 per cent of rural homes in Illinois and 45.5 per cent of those in the entire United States, had piped, running water. Here is a rapidly changing aspect of the national scene.

Projection Techniques

The Bureau of the Census has made illustrative projections of the population of the United States and of the several states (*6*). Although events of the last two decades have given demographers less confidence in their forecasts than they once had, these projections are still among the best available. Estimates based on several anticipated fertility rates are provided. In addition, projections have been made both by the "component" and the "ratio" method. The authors have used the highest estimates in order to insure that the most demanding situation will receive consideration (Fig. 4). Using these data, together with urban and rural total ratios projected by the authors, the urban and rural

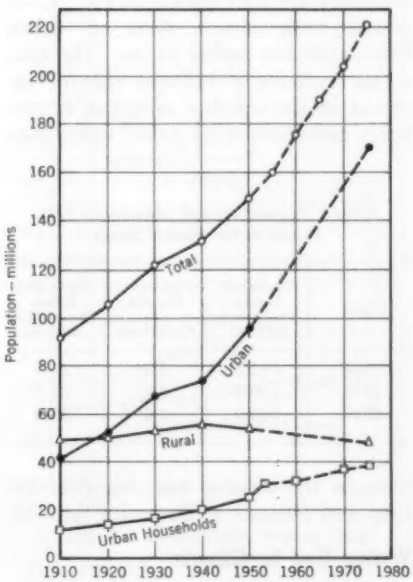


Fig. 4. Population Growth Projections, United States, 1910–1975

populations for the United States have been estimated to 1975.

Figure 4 suggests that an increasing proportion of the population will be living under urban circumstances, and will expect service from public water supply systems.

The population forecasts can be combined with estimates of household size to yield forecasts of urban households, as shown in Table 1. These estimates are also shown in Fig. 4, together with census data on urban households for earlier years. The estimates indicate a reduced rate of increase in the number of urban households to be served by public water supplies in the coming two decades, but they also indicate a continuing growth.

TABLE 1

Urban Population and Household Size Forecasts for United States

Year	Projected Urban Population *millions*	Estimated Persons per Household	Estimated Urban Households *millions*
1960	113.8	3.5	32.5
1970	130.7	3.6	36.3
1975	140.0	3.6	38.9

Water Use in Illinois

Experiences in Illinois communities of small to medium size are illuminating. It should be kept in mind that the following figures cover only residential sales.

Figure 5 portrays the results of the data on residential water use collected at two Illinois municipalities, towns *A* and *C*, with populations of 1,600 and 5,600, respectively, which receive water from impounding reservoirs. At town *A* there were slight overall increases in gallons per capita and gallons per service from the earliest records to 1952, in which year restrictions on water use were initiated because of drought. The percentage of population served showed a gradual increase in service from 46 per cent of the population in 1939 to 93 per cent in 1954.

Town *C* showed slight increases in gallons per capita and gallons per service from 1942 to 1953. In 1953 restrictions were initiated. The per cent of population served increased sharply from 1942 to 1946 and then remained fairly level at 91 per cent to 1954. This town, a thriving coal-mining community prior to 1930, suffered a population loss of 35 per cent from 1920 to 1950 because the mines became worked out. In 1920 the number of persons per household was 4.67, or 10 per cent higher than the averages for Illinois and the United States, but

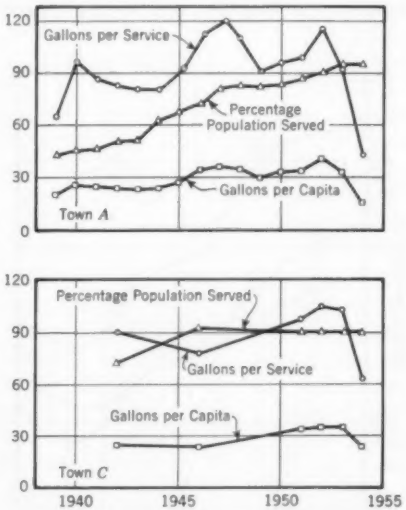


Fig. 5. Residential Water Use, Towns *A* and *C*

Data are shown for Illinois towns A *and* C, *with populations of 1,600 and 5,600, respectively.*

in 1950 the number was about 2.9, or 12 per cent below the Illinois and United States averages.

Contrary to the general experience in towns where water use restrictions have been lifted, the residents of town *C* discovered they could get along with the water shortage. When the reservoir began spilling over, they were not inclined to return to the basis of pre-drought use of water, so that today the water department, with increased expenses, is plagued with an unanticipated shortage in revenue.

Figure 6 portrays the residential water use data for *H* and *J*, towns of 18,000 and 41,000 population, respectively, and both with considerable commercial and industrial water use. Town *H* obtains water from a surface reservoir supplemented by a limited ground water supply. Town *J* receives water from the Mississippi River. The three graphs for each town are quite similar from the beginning of their records to 1955 except that town *H*, because of the drought, used all its reservoir supply about 1953, and, with the well supply not sufficient to carry the load, required restrictions in water use.

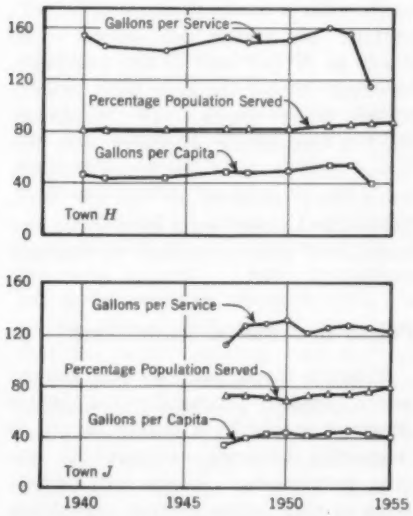


Fig. 6. Residential Water Use, Towns *H* and *J*

Data are shown for Illinois towns H *and* J, *with populations of 18,000 and 41,000, respectively.*

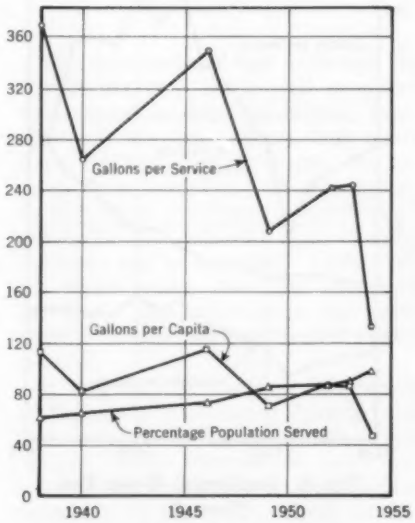


Fig. 7. Residential Water Use, Town *F*

Data are shown for Illinois town F, *with a population of 9,500. Low pumpage in 1949 reflects 20 per cent rate increase. Low in 1954 reflects institution of full restrictions in December 1953.*

Figure 7 has been prepared for *F*, a town of 9,500 population, largely composed of retired farm families, with a water supply obtained from a surface reservoir. In the early 1930's, when the customers were charged on a flat-rate basis, a record of 2.25 mil gal was pumped for one day and the annual average rate of pumping was 1.5 mgd.

Eight months after meters had been installed on all the services, the summer peak was 0.6 mgd and the January–July average was 0.46 mgd, a drop of 66 per cent. By 1946 there was another runaway in residential water use, with an average in July of 1.1 mgd. Rates were increased 20 per cent in 1949. Again the pumpage dropped to

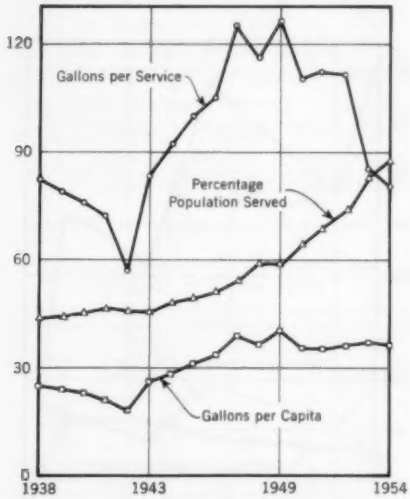


Fig. 8. Residential Water Use, Town *E*

The town has a population of 5,700, and derives its water supply chiefly from wells and springs. Marked decline in gallons per service in 1952–53 occurred simultaneously with gradual increase in percentage of population served. Losses through leaks in corroded water mains accounted for 27 per cent of pumpage until 1954, when this figure was reduced to 18 per cent.

0.6 mgd, 45 per cent below the July 1946 average. In December 1953, full restrictions were instituted because the reservoir was depleted, not only as a result of the drought but also because customers were allowing water to drip to waste to prevent freezing of pipes.

Figure 8 has been prepared from the water use data for *E*, a town of 5,700 population, located in a prosperous agricultural area, with a water supply from wells and springs. The curves for residential use show gallons per capita and gallons per service figures comparable to those of other Illinois towns in the same population bracket. In 1952–53, a noticeable decline in gallons per service occurred simultaneously with a gradual increase in percentage of population served. As much as 27 per cent of the pumpage, however, is lost through leaks in corroded water mains. In November 1953 a consulting engineer was retained, and in 1954 the losses through leaks were reduced to 18 per cent. Subsequent losses were apparently not considered serious enough to warrant repair.

Public Reaction to Restrictions

When a municipally owned, ground water system encounters a water shortage caused by a failing supply, it frequently becomes necessary to impose restrictions. When such restrictions as prohibition of lawn sprinkling and car washing do not meet the emergency, it becomes necessary to shut off water use for all-night periods and, later, for intermittent periods in the daytime "while the tank is being filled." When such extreme measures are necessary, the customers generally become accustomed to the unsatisfactory operation and gradually develop a tolerant attitude toward the water works officials.

The officials of a municipally owned surface water system may find it difficult, as a drought period becomes extended, to convince the customers that the capacity of their lake is becoming critically low—that the broad water

TABLE 2

Electric Water-using Appliances in United States and Illinois Homes, 1949–55 *

Area	Millions Wired Homes	Millions Wired Homes With:				Percentage Wired Homes With:			
		Dish Washers	Food Waste Disposers	Water Heaters	Clothes Washers†	Dish Washers	Food Waste Disposers	Water Heaters	Clothes Washers†
United States	46.0	1.84	2.55	7.50	38.70	4.0	5.6	16.3	84.1
Illinois	2.0	0.042	0.062	0.093	0.994	2.2	3.2	4.8	51.0

* Index of saturation Dec. 31, 1955.
† Includes automatic and conventional types.

surface which they see may be only a very few feet above the lakebed.

In one of the communities studied but not discussed herein, city officials instituted restrictions during 1953, prohibiting the washing of cars and the sprinkling of lawns. A reduction in residential use of approximately 26 per cent ensued. These restrictions had to be continued through 1954, and by the end of that year it was found that the water revenue had declined so severely that the water system was running into debt at a rapid rate. Officials thereupon reported this fact to the community and recommended a substantial increase in water rates to rectify the financial situation. The response of the citizenry was to elect new officials who, by drastic curtailment of both essential and nonessential expenditures, managed to bring the water department books into a current operating balance.

Domestic Water-using Appliances

The most serious likelihood of increased residential use of water may result from the installation of water-using appliances in the home. Table 2 shows the number of water-using appliances installed in homes during the years 1949–55 inclusive for Illinois and for the United States. Installations prior to 1949 are not known.

The data indicate that, although the market has been fairly well saturated with home washing machines, comparatively few dishwashers, food waste disposers and electric water heaters have been installed. A continuing trend toward increased installation of automatic and conventional washing machines can be expected. Only electric water heater sales are shown in the data. No information has been made available on gas water heater sales.

It may also be assumed that nearly all the newer water-using devices have been installed in higher-income urban centers. Large increases in water use in small communities can therefore be expected. Similarly, the small saturation indexes for dishwashers and food waste disposers point toward considerable increases in per capita use in the larger communities. It is reasonable to assume that there may be a trend toward the air-cooled home air conditioner in preference to the water-cooled type.

Effective Family Buying Income

A study (*10*) by the Illinois State Water Survey indicated residential water use in 1948 to be related to the family income of the community. A survey made by *Sales Management* magazine (*11*) in 1956 gives data on the effective net family income buying power for all communities over 10,000

population. Table 3 presents data from this survey for the Illinois communities discussed herein. Because three of the communities—*A*, *C*, and *D*—have less than 10,000 population, the county average was used.

Also shown in Table 3 are the gallons per day per service and the gallons per day per capita for the three towns. Fig. 9 is a graphical relationship of residential daily use per

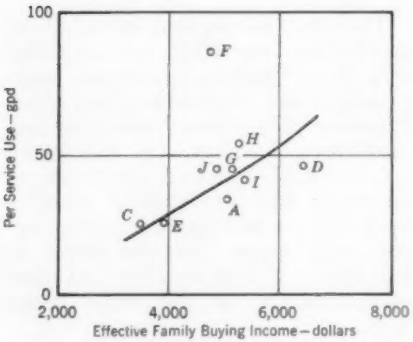


Fig. 9. Net Effective Family Buying Income and Residential Daily Use per Service, Illinois Towns

service and net effective family buying income. Gallons per service are used in the graph because this figure more closely represents the use per family. (In plotting gallons per capita and net family income a similar straight-line correlation is produced.) In this graph the data for town *F* are not given weight because of the poor record of residential water use by this community. The data for town *H* are lightly considered because the record of the number of services for that community was occasionally interpolated. The data for town *D* were given strong consideration because the water records were well kept, and because the water use per capita as well as per service is keeping pace with the higher family income of this community.

The communities considered in this report are none of those used in the earlier (*10*) study, but the correlation between residential water use and family buying income corresponds very well.

Projections for Illinois

The data from nine Illinois towns in which the water records were found to be fairly comprehensive have been assembled in two groups. Group I is composed of four towns in the population range of 15,000–50,000. In Group II are five towns having populations of less than 10,000. By inspection of the per capita graphs for the individual towns, it was seen that the residential consumption in 1952 for the towns in Group I averaged about 48 gpd per capita. For the Group II towns the residential consumption in 1952 averaged 35 gpd per capita.

TABLE 3

Relation of Effective Family Buying Income to Residential Water Use, Illinois Communities

Community	Family Buying Income $	Residential Use	
		Per Service *gpd*	Per Capita *gpd*
A	5,035*	116	34
C	3,517*	105	36
D	6,412*	171	46
E	3,958	112	36
F	4,743	244	87
G	5,179	131	45
H	5,250	160	55
I	5,325	129	45
J	4,941	128	45

* County average.

Figure 10 has been prepared from the weighted averages for residential consumption of gallons per capita and gallons per service for Group I. Figure 11 shows the weighted averages of gallons per capita and gallons per service for Group II. The data for both groups were plotted for 1951 and prior years, as the 1952 to 1954 records reflected the effect of the restrictions instituted during the drought.

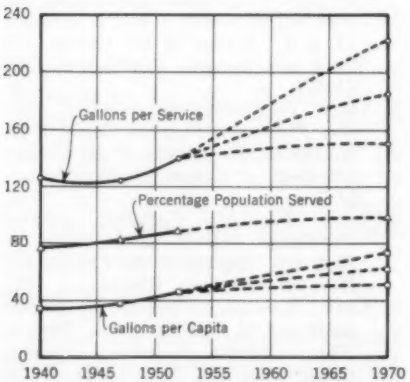


Fig. 10. Residential Water Use, Four Illinois Towns (Group I)

Curves shown were prepared from weighted averages for residential consumption in four Illinois towns in the population range of 15,000–50,000. Broken-line curves beyond 1952 indicate maximum, average, and minimum projections. Data from 1952–54 were not plotted because of the effect of restrictions instituted during the drought.

In designing the projections for residential gallons per capita (Fig. 10), consideration has been given to the slope of the curve for the period just prior to 1952, when homes in cities of this size were being equipped with water-using appliances. A saturation of less than 50 per cent had been reached by 1956, and this was considered a good reason for extending the maximum projection at this same slope to 1970. The minimum projection has been extended with very little increase in slope from 1952 to 1970.

For Group II (Fig. 11) consideration was given to the fact that up to 1952, a negligible number of homes in towns of this population range, were equipped with water-using appliances. By 1956, however, the economic status

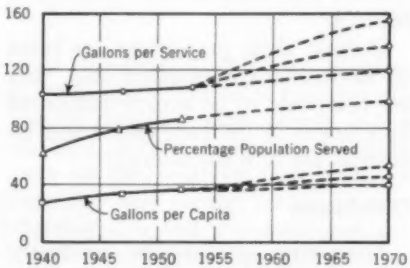


Fig. 11. Residential Water Use, Five Illinois Towns (Group II)

Curves were prepared as described in Fig. 10 for five Illinois towns of less than 10,000 population.

of these towns was improved and the net family buying income was up. Giving consideration to these factors, the maximum projection to 1970 was designed on the same slope as that used for the towns in Group I.

The gallons per service graphs represent family use of water, and a fairly close check of the projections is observed when multiplying any point on the gallons per capita curve by the Bureau of the Census' estimated average of 3.03 persons per family.

There is need to consider other factors in future planning. One of these other factors is the availability of public sewer service, which in many small communities did not become available

until after 1930, and which undoubtedly stimulated the increasing installation of waterborne waste disposal methods.

It seems obvious that both per capita and per service demands will rise in these communities. Conservative planning dictates the necessity of estimating future trends generously. Although maximum, medium, and minimum estimates are plotted, it is recommended that the maximum projections be used.

Because these projections are based on residential consumption only, they are not likely to be greatly influenced by changes in the commercial and industrial life of a community.

Conclusion

Misleading estimates of residential water use result from failure to consider trends in such socio-economic factors as family size, proportion of urban population served, and the installation of water-using appliances in homes. Data by which these influences may be measured are available, and should be used. For the near future, these data indicate slower increases in number of services to be installed. An increase in unit residential uses of water, however, will cause a continuing rise in demands placed on water works systems.

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South Carolina's Golden Strip Water District

Joint Discussion

A joint discussion presented on Mar. 20, 1956, at the Southeastern Section Meeting, Augusta, Ga.

Development and Design—*Edward E. Bolls Jr.*

A paper presented by Edward E. Bolls Jr., Civ. Engr., Black & Veatch, Cons. Engrs., Kansas City, Mo.

THE development and design of the facilities for the Mauldin-Simpsonville-Fountain Inn Water District should be of particular interest to the water works industry as proof of the ability of a determined group of people to overcome obstacles that sometimes appeared insurmountable.

Origin of Project

Water was made available through the district's system in January 1954, but the concentrated effort of the persons who made this development possible began in 1949 or earlier. In the fall of 1950, leading citizens of Simpsonville and Fountain Inn, S.C., had several conferences with John Hawkins, superintendent of the Greenville city water works, and with representatives of the Greenville County Planning and Development Board. As a result of these conferences, it was decided that the towns of Simpsonville and Fountain Inn would serve as joint sponsors of an engineering study to determine the feasibility of a district water system.

In January 1951, the firm of Black and Veatch was retained to prepare this feasibility study. At the conclusion of its field investigations for this project, it was apparent that the proposed district had all of the requirements for the attraction of industry except an adequate water supply. The proposed district extended 15 miles south of the southern city limits of Greenville, and, for this entire distance, Highway 276 and a parallel railroad provided excellent transportation to some of the finest industrial sites in the Piedmont Plateau area. Natural gas was being made available to the area—which left only water lacking.

The existing development within the district included the town of Mauldin, approximately 5 miles south of the Greenville city limits, the town of Simpsonville, 9½ miles from Greenville, and the town of Fountain Inn, 13½ miles below Greenville. Although Simpsonville and Fountain Inn had municipal well supplies, the residents of Mauldin were served by private wells, all of which were of very small capacity and had histories of short life and decreasing capacity.

The studies determined that a supply from the Greenville city water works offered the most feasible solution to the water problem. Negotiations were started with the Greenville Commission of Public Works, and that board gave its consent to provision of water service to the district.

At the time of the feasibility study, the district contained 1,290 potential customers in the area lying one mile on each side of the 15 mile distance along Highway 276. Minimum future demands were based on serving 2,580 customers, or twice the existing population, plus the existing textile mills. On this basis it was determined that the minimum system capacity should be 1.4 mgd.

As the primary purpose of the establishment of the water district was to attract new industry to the area, it was essential to provide additional capacity for industry, and the next step in the study consisted of financial investigations to determine what capacity could be provided.

Financing

It was soon apparent that no reasonable schedule of water rates would finance the necessary improvement program and it was obvious that a special tax assessment would be required to assist in financing the issue. It was subsequently determined that the total assessed valuation in the district was approximately $1,600,000.

The suggested water rate schedule proposed a minimum bill of $2.00 per month for the first 2,500 gal, $0.50 per 1,000 gal for the next 7,500 gal, and $0.20 per 1,000 gal for all usage over 10,000 gal. With this rate schedule and with a reasonable millage against the assessed valuation, it was determined that the bond issue should be limited to approximately $900,000.

As a result of these financial limitations, and in order to provide the district with surplus funds for initial operations, it was recommended that a 16-in. transmission line be constructed from Greenville to Fountain Inn, a distance of approximately 71,000 ft. This project was estimated to cost approximately $700,000.

Details of Construction

The topography of the area was well suited to a transmission line from Greenville, as the route was generally downhill for the entire length of the line. At the Greenville city limits the ground elevation is 1,000 ft above sea level, as compared to about 900 ft at Fountain Inn. With a 16-in. pipeline, at flow rates of 2.6 mgd, the hydraulic gradient is approximately parallel to the slope of the ground, and no booster pumping is required to maintain 130 ft of residual head at Fountain Inn. Pressure-reducing valves were installed at two points on the line to limit the downstream pressures during periods of minimum flow.

The proposed improvements include the addition of an elevated tank between Simpsonville and Fountain Inn when the consumption approaches the capacity of the pipeline. With this tank in service, the system will be capable of supplying peak-day demands of 2.75 mgd and peak-hour demands of 4.25 mgd.

Conclusions

Those who operate large systems may not appreciate the magnitude of this project unless it is placed in the proper perspective. It should be considered that this group of small communities obligated itself to a bond issue that represented over one-half its total assessed valuation. It financed and constructed a water system having a capacity of seven times the existing peak demands. This district contained three centers of population, each with water supplies of varying degrees of

adequacy. In each of these population centers there were persons who felt that no such program was needed, with consequent differences of opinion concerning the allocations of cost to the various customers. All of these obstacles were recognized and handled through public meetings with interested citizens.

The results of the efforts of the persons who led this movement for the development of a centralized water district are best indicated by the vote on the bond issue: 830 for and 13 against. This vote of 64 to 1 in favor of the district is ample evidence of the faith of a group of persons in the future of their community.

Effect on the Community—*James C. Cousins*

A paper presented by J. C. Cousins, Supt., Mauldin-Simpsonville-Fountain Inn Water District, Simpsonville, S.C.

Since completion of a 16-in. transmission main to provide an adequate water supply for the 30-sq mile area, (a strip 15 miles long and 2 miles wide), the citizens of the Mauldin-Simpsonville-Fountain Inn Water Distric can be and are justly proud of the area's "growing pains." The system was completed on Dec. 16, 1953, at which time a well water supply was discontinued and water from Greenville's Table Rock Reservoir was substituted.

Results of Construction

When the water district operation began, the towns of Simpsonville and Fountain Inn were serving 891 customers, and, with the immediate addition of another 154 customers in Simpsonville, whom the town was unable to supply, the total became 1,045. As an indication of the growing pains the water district today serves 1,650 customers which is an increase of approximately 58 per cent. This increase results from service to some 250 homes formerly using private wells, and the addition of 350 new homes and industries.

Although Mauldin, another growing community in this district, had no previous water distribution system, its citizens financed the installation of approximately $35,000 worth of lateral water lines for their community almost before the transmission line had been completed.

In just over 2 years of operation approximately 100,000 ft of additional lateral lines—varying in size from 2–8 in.—have been laid. In several locations, lateral lines have been laid the entire width of the district. Water for this district is metered through an 8-in. meter at the Greenville city limits. Consumption was approximately 350,000 gpd after some 6 months of operation, reaching 600,000 gpd by the end of 1955. The peak demand during summer seasons has been slightly over 1 mgd.

Industrial development, which had long been desired, began to increase after completion of the new water system. Plants for the manufacture of underclothing and household products were constructed during installation of the water main. Food processing and sportswear plants were also built, and another, located in Simpsonville, has just begun operation, manufacturing plastic food-preserving containers. A clothing finishing plant built in Foun-

tain Inn in 1951 on the strength that an adequate water supply would be provided for increased production has already doubled its original consumption. These industries alone have provided employment for some 1,500 persons—mostly from this area.

In Mauldin, such improvements may be noted as the construction of a new first-class post office and a new bank, many new homes, and the reconditioning of many of its present business places. Fountain Inn is proud of its new, privately owned and operated, modern, twelve-room clinic, its newly established bank and residential and industrial developments.

Since completion of the transmission main, property values have doubled and, in some cases, more than tripled. Now, even those landowners formerly opposed to such a project (because of the special tax levy), agree that they, too, will benefit from such a system even though it may be years before some will have water available.

Financial Aspects

Only $650,000 of the district's $900,000 bond issue was spent on the original construction. The remaining funds are invested in government bonds which are sold, as needed, to pay for the lateral lines built by developers. Such lines, installed according to the district's specifications, are paid for when they provide an annual revenue equal to 10 per cent of their original cost.

Water revenue for the district in 1954 was slightly more than $68,000, and that for 1955 was approximately $77,000. Revenue received from the 17-mill special tax levy in 1954 was $35,500; the same levy in 1955 provided $36,600. The total revenue in 1955 was $113,600 and operating expense and annual debt service on the bond issue, including interest and principal, amounted to $99,900.

Numerous inquiries about the success of this project have come to the author's office, and already several neighboring sections that have noted the district's progress have begun legal proceedings toward establishing a water district for their communities.

The water district office and warehouse was constructed in Simpsonville, which is now called "The Heart of the Golden Strip." The office is equipped with a mechanical billing system which provides efficient billing and crediting of accounts. Meters are read monthly and bills rendered the first day of the month. Most outstanding is the user's change in attitude toward payment of bills. With new meters being installed (about 500 of the original 891 have been replaced) and no restrictions on the use of a high-quality water, the district now deals with a more satisfied customer.

Conclusion

With the present expansions and the anticipated developments it can most certainly be said that all the effort and money spent for the completion of such a project have not been in vain. Largely because of the new water system, the citizens of the Mauldin-Simpsonville-Fountain Inn Water District, seem headed toward a more prosperous era than this section has ever known. They are now justly boastful of the establishment of the system in this rural area, and feel that no misrepresentation was made when this section was labeled "The Golden Strip."

Destruction of Microorganisms in Water, Sewage, and Sewage Sludge by Ionizing Radiations

Harry N. Lowe Jr., William J. Lacy, Bernard F. Surkiewicz, and Robert F. Jaeger

A paper presented on Nov. 8, 1956, at the Virginia Section Meeting, Old Point Comfort, Va., by Harry N. Lowe Jr., Chief Engr., and William J. Lacy, Project Engr., both of the San. Eng. Branch, Engineer Research & Development Labs., US Army Corps of Engineers, Fort Belvoir, Va.; and Bernard F. Surkiewicz and Robert F. Jaeger, both Bacteriologists with the US Army Chemical Corps, Fort Detrick, Frederick, Md. The conclusions stated or implied in this paper are those of the authors and are not necessarily the official views of either the Corps of Engineers or the Chemical Corps, US Army.

THE increasing accessibility of radioactive materials has stimulated interest in the general field of sterilization by ionizing radiations. A recently published literature survey (*1*) on the effects and utilization of ionizing radiations, with special reference to food and packaging technology, listed a total of 2,939 reference sources. Although considerable work has been reported on the sterilization of food and drugs, very little information is available on the destruction by irradiation of microorganisms in water, sewage, and sewage sludge.

The preliminary experiments under this project were conducted at the Oak Ridge Test Station of the Engineer Research and Development Laboratories in April 1954. Samples of a mixture of 50 per cent distilled water and 50 per cent effluent from the primary settling tank of the Oak Ridge National Laboratory (ORNL) sewage treatment plant were exposed to gamma radiation from a 10-kilocurie cobalt-60 source. The rate was 1.72×10^6 rad * per hour. Five dosages were used: 5×10^4, 1×10^5, 5×10^5, 1×10^6, and 5×10^6 rad. In the range of 5×10^4 rad to 1×10^6 rad, the gross kill of bacteria was essentially constant—about 93 per cent. Apparent sterility was attained at the highest dosage of 5×10^6 rad. These data suggested additional experimentation using pure cultures of test organisms as well as settled sewage and sewage sludge. The microorganisms selected for further study were *Bacillus subtilis* var. *niger*, *Mycobacterium smegmatus*, *Micrococcus pyogenes* var. *aureus*, *Esch. coli*, and *Esch. coli* phage T3. The results of these experiments, conducted at the Oak Ridge National Laboratory in January 1956, are the subject of this paper.

Source and Shield

The gamma source was approximately 1,100 curies of cobalt-60 pre-

* Radiation absorbed dose, equivalent to 100 ergs per gram of material (National Bureau of Standards Handbook 59).

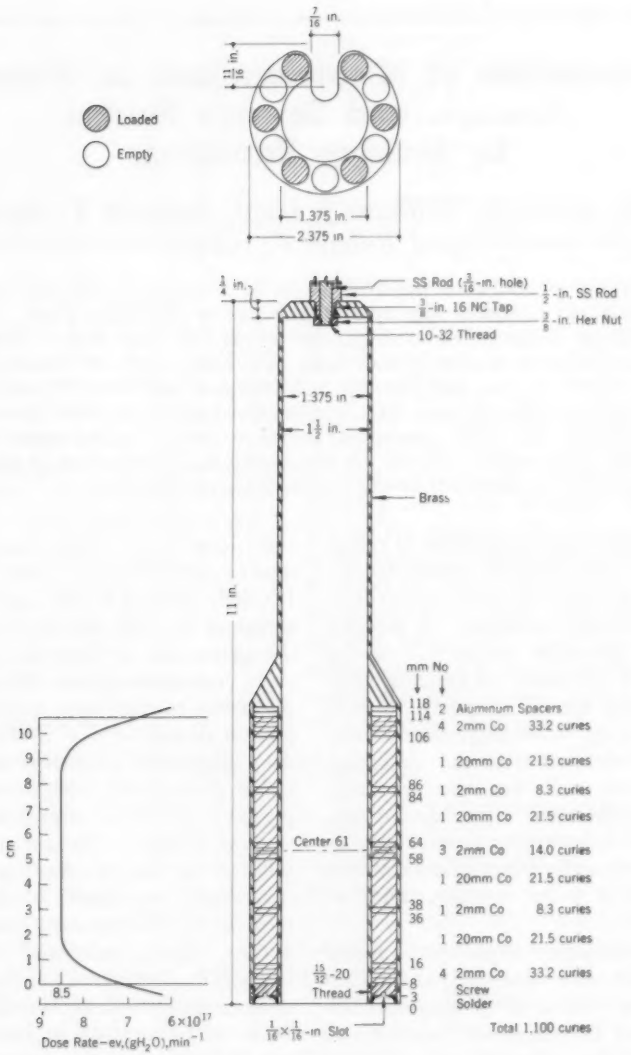


Fig. 1. Cobalt-60 Source

A cross-sectional view of cobalt-60 source used in irradiation studies is shown. Note dose rate curve at lower left. (Courtesy Oak Ridge National Laboratory.)

pared by neutron irradiation of cobalt-59 in the materials-testing reactor. The material was in the form of metal cylinders 1 cm in diameter and 1 cm long. The cylinders (pellets) were loaded into peripheral holes

in the wall of a hollow brass cylinder, thereby providing a uniform intensity distribution along the longitudinal axis (*see* Fig. 1). A more complete description of the source is given by Ghormley and Hochanadel (*2*).

The shield for the source was constructed in two sections, as shown in Fig. 2. The bottom section was a large block of lead containing two cavities in which samples could be placed for irradiation. The top section, which normally housed the cobalt-60, was a lead cylinder in an iron can mounted on a dolly (*see* Fig. 3). The dolly could be rolled on tracks over either cavity, permitting the brass cylinder containing the cobalt to be lowered into the bottom section. The entire shield contained about 6 tons of lead and provided a minimum of 10 in. of lead shielding with the source in any position.

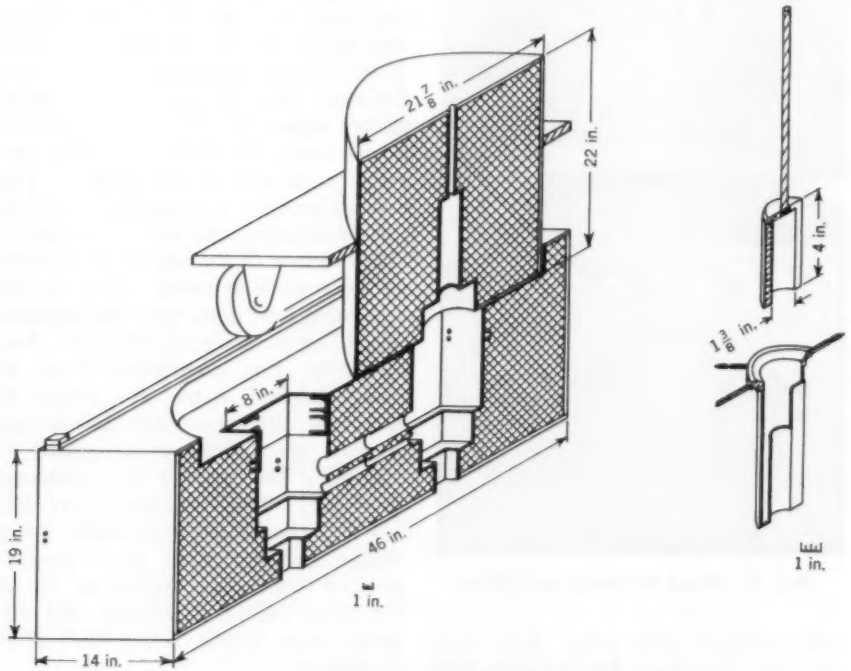


Fig. 2. Cobalt-60 Gamma-Radiation Shield

Test Procedure

The test organisms were exposed to radiation under two different environmental conditions: [1] suspended in double-distilled sterilized water and [2] suspended in settled sewage previously sterilized by autoclaving.

In the first series of experiments, test tubes, each containing about 50 ml of sterile double-distilled water, were inoculated with the test organism to a concentration of approximately 10^6 organisms per milliliter. Just prior to irradiation, samples were taken from each tube and plated to determine the initial concentration of test organisms.

With each organism, six to eight samples in 25 × 150 mm pyrex test tubes were irradiated, the dosages ranging from 5×10^3 to 5×10^6 rad. Samples were taken from each tube immediately after irradiation and plated to determine the number of organisms that survived each dose. One tube was not irradiated, but was sampled at intervals to determine the normal death rate of the test organisms. Aluminum foil was used to stopper the tubes.

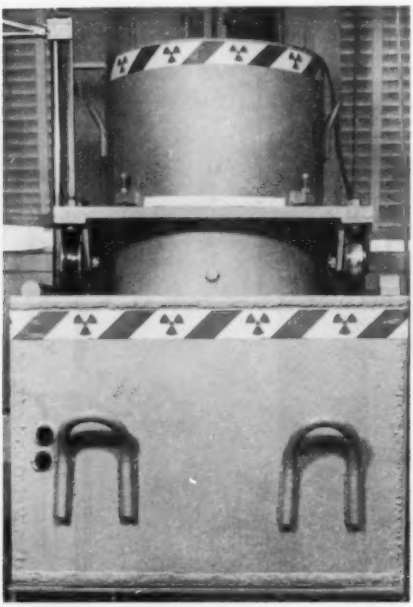


Fig. 3. Cobalt-60 Shield and Dolly

In the second series of experiments, the procedure described above was repeated with the test organisms suspended in sterilized settled sewage in place of distilled water.

The test procedure for irradiation of unsterilized settled sewage was essentially the same as described above except that no test organisms were added. No attempt was made to identify the viable organisms present.

The experiments on sewage sludge were made using the material: [1] as it was received from the drying beds (moisture content 87 per cent) and [2] in 5-g samples in 45 ml of distilled water. In the first instance, 5 g of sludge was added to each of thirteen test tubes, and to four of these there was added 45 ml of double-distilled water. These four tubes were not irradiated. Instead, after the tubes were shaken vigorously, aliquots were plated to determine the number of viable organisms present in the sludge. The average number of organisms found in these four tubes was used as a reasonable estimate of the organisms present in the remaining tubes. Each of the remaining nine tubes was then exposed to a different dosage of radiation. Immediately after irradiation, 45 ml of double-distilled water was added to each tube, the tubes were shaken vigorously, and aliquots were plated to determine the number of organisms surviving. This procedure was followed in the second experiment, using sludge, except that 45 ml of double-distilled water was added to all of the tubes before irradiation and aliquots were plated before and after irradiation.

The plating medium known at Fort Detrick, Md., as "103 nutrient agar" was used throughout these experiments. The growth characteristics on this agar for each of the test organisms had been determined in prior work. Except for *Micobacterium smegmatus,* incubation was at 37°C for 48 hr. *Micobacterium smegmatus* was incubated at 37°C for a period of not less than 60 hr, due to a slower rate of colonization.

Test Results

The results of these experiments are summarized in Fig. 4 and 5. Some difference was noted in the radiation sensitivity of a given test organism, depending upon the liquid in which it was suspended. The range of results is shown in Table 1. *Bacillus subtilis, Mycobacterium smegmatus, Micrococcus pyogenes* var. *aureus,* and *Esch.*

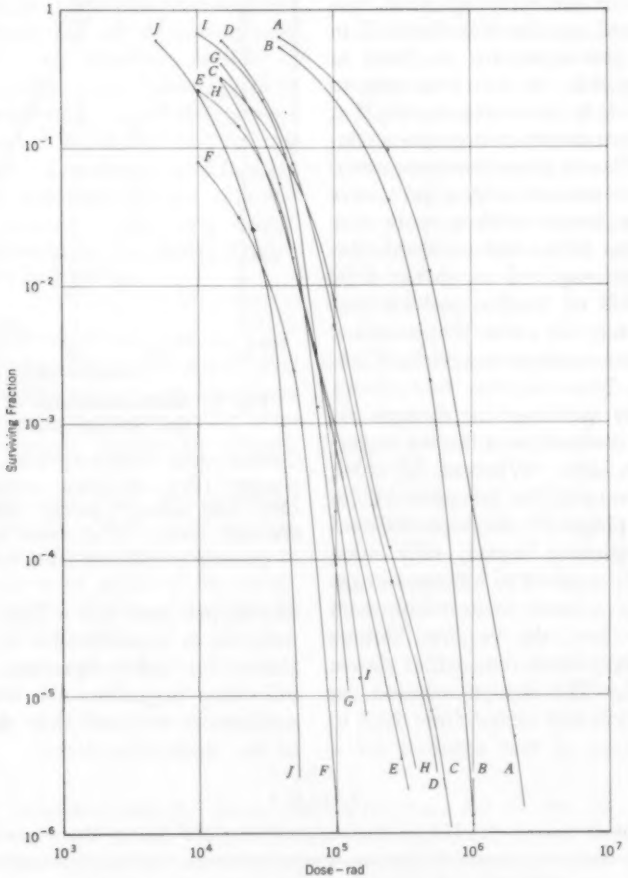


Fig. 4. Radiosensitivity of Selected Microorganisms

Surviving fractions of selected microorganisms, suspended in distilled water and sterilized sewage, when exposed to cobalt-60 gamma irradiation, are shown. Curves represent following suspensions: Bacillus subtilis *var.* niger (A—*in distilled water,* B—*in sterilized sewage*); Mycobacterium smegmatus (C—*in distilled water,* D—*in sterilized sewage*); Esch. coli (E—*in distilled water,* F—*in sterilized sewage*); Micrococcus pyogenes *var.* aureus (G—*in distilled water,* H—*in sterilized sewage;* Esch. coli *phage T3* (I—*in distilled water,* J—*in sterilized sewage*).

coli phage T3 were more susceptible to death by gamma irradiation when suspended in distilled water, while *Esch. coli* was more susceptible when suspended in sterilized settled sewage.

A marked difference in the radiosensitivity of the test organisms was demonstrated, as shown in Table 2, in which the test organisms are listed in descending order of their resistance to radiation. It is interesting to note that the two most resistant organisms, *Bacillus subtilis* and *Mycobacterium smegmatus,* are endowed with a protective sheath, the former with a spore case and the latter with a wax encapsulation. The dosage required to obtain a 99 per cent kill of *Bacillus subtilis* was approximately 11 times that required for the least resistant organism, *Esch. coli* phage T3.

Generally speaking, the dosages required for destruction of the test organisms were high. Whereas 7.5×10^4 rad was required for complete kill of *Esch. coli* phage T3, the least resistant of the organisms tested, only 400–1,800 rad is required to kill most mammals. For a more modest kill, such as 90 per cent, the required dosage would be very much reduced, as shown in Table 3. The dosage required for a 90 per cent kill varied from 12.2 to 32.8 per cent of that required for a 99.999 per cent kill. This statistical variation is characteristic of the death curves for microorganisms. A few individual organisms are usually very much more resistant than the average to any destructive force.

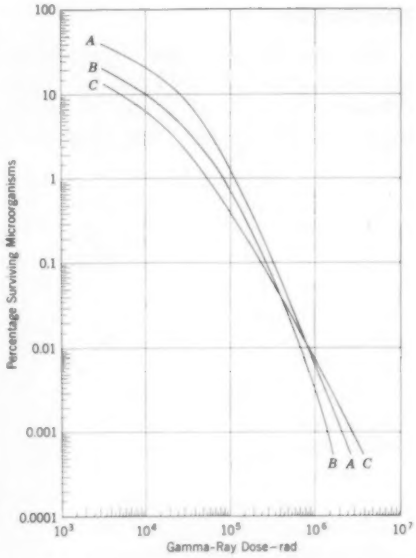


Fig. 5. Radiosensitivity of Sewage and Sewage Sludge

Curves show radiosensitivity of settled sewage (A), *air-dried sewage sludge* (B), *and sewage sludge suspended in distilled water* (C), *when exposed to gamma irradiation from cobalt-60.*

TABLE 1

Cobalt-60 Gamma-Ray Dosage Required for 99 Per Cent Kill of Microorganisms

Microorganism	Dosage Required—*rad*	
	Distilled Water	Sterilized Sewage
Bacillus subtilis var. *niger*	3.4×10^5	5.0×10^5
Mycobacterium smegmatus	1.4×10^5	1.6×10^5
Esch. coli	6.5×10^4	2.6×10^4
Micrococcus pyogenes var. *aureus*	5.8×10^4	7.4×10^4
Esch. coli phage T3	3.2×10^4	6.2×10^4

Partial results of tests using settled sewage and sludge are shown in Table 4. Both materials were subjected to dosages sufficiently high to obtain apparent sterilization. The dosage of 1.2×10^5 rad for a 99 per cent kill in settled sewage is less than that required for an equal kill of *Mycobacterium smegmatus* and *Bacillus subtilis* in sterilized sewage (*see* Table 2). The dosages required for equal effects were lower for air-dried sludge than for settled sewage. The dosage of 5.0×10^6 rad for an apparent 100 per cent kill in settled sewage is the same dosage found necessary in the initial experiments described earlier.

Conclusions

Examination of the data shows that it is possible to kill or inactivate microorganisms in water, settled sewage, and sewage sludge by gamma irradation.

The most significant fact apparent from this study is that, with the exception of *Bacillus subtilis*, kills up to 90 per cent were achieved in water, settled sewage, and sewage sludge with dosages no larger than 7×10^4 rad. For a 99 per cent kill, the required dosage was about 1.5×10^5 rad. In considering possible future applications of ionizing radiation on water, sewage, or sludge, it is these dosages that must be evaluated, not the very high dosages required for apparent sterilization. Even with a relatively cheap source of radiation, the use of sterilizing dosages of beta and gamma radiation would seem to be restricted to products of high value per unit of weight, such as food and drugs.

Hydrogen peroxide is produced by irradiating water containing dissolved hydrogen and oxygen with gamma rays. Initially, each free H and OH radical produced as intermediate products in this radialysis of water, reacts with hydrogen or oxygen and is converted to peroxide. As the peroxide builds up in solution, it competes for the radicals, thereby leading to a steady-state concentration of H_2O_2, H_2, and O_2. According to Sworski (*3*), the maximum theoretical yield of peroxide formed in a sample of distilled water at 25°C irradiated to 5×10^6 roentgens, would be about 1.7 ppm. The yield of peroxide obtained experimentally in these tests, using a modification of the iodometric titration method, was 3.8 ppm. In every instance 0.5 ml of sterile aqueous 0.15 per cent sodium thiosulfate was added to each petri dish to neutralize any

TABLE 2

Cobalt-60 Gamma-Ray Dosage Required for 99 and 100 Per Cent Kill of Microorganisms in Distilled Water

Microorganism	Dosage Required—*rad*	
	99% Kill	100% Kill
Bacillus subtilis	3.4×10^5	2.0×10^6
Mycobacterium smegmatus	1.4×10^5	1.0×10^6
Esch. coli	6.5×10^4	4.0×10^5
Micrococcus pyogenes var. *aureus*	5.8×10^4	2.5×10^5
Esch. coli phage T3	3.2×10^4	7.5×10^4

traces of H_2O_2 present in the irradiated samples. The same amount of sodium thiosulfate was added to the petri dish of the nonirradiated samples.

The absorption of energy in the test samples was accompanied by a rise in temperature. For example, the temperature of the samples exposed to 5×10^6 rad went from 22°C to 35°C, while the control sample remained at 22°C. It is believed that the temperature rise in this case did not have a significant effect on the results obtained.

TABLE 3

Cobalt-60 Gamma-Ray Dosage Required for 90 and 99.999 Per Cent Kill of Microorganisms in Distilled Water

Microorganism	Dosage Required—*rad*	
	90% Kill	99.999% Kill
Bacillus subtilis	1.8×10^5	1.1×10^6
Mycobacterium smegmatus	6.6×10^4	5.4×10^5
Micrococcus pyogenes var. *aureus*	3.5×10^4	1.4×10^5
Esch. coli	2.7×10^4	2.1×10^5
Esch. coli phage T3	1.9×10^4	5.8×10^4

Gamma rays can induce activity in certain elements, such as ruthenium, silver, cadmium, indium, gold, and lead. In these cases the ground state isotope is excited to an isomeric state by the gamma rays. The isomer then decays according to its characteristic half life and energy. The process of excitation is frequently termed a "line absorption." As the rays of only a narrow energy range will induce activity in one of the specific elements, the probability of excitation is very small. Nehemis and associates (*4*) reported that in samples of food exposed for 2 weeks at 220,000 rep * per hour, the level of induced activity would be detected only with a very sensitive scintillation counter. Residual activity in the irradiated water, settled sewage, and sewage sludge in these experiments was too low to be detected.

This series of experiments should be considered only as having produced information in an area where there is limited guidance in the literature (*5–20*). No attempt was made to evaluate many of the variables that could influence the data presented. The effects of dosage rate and organism concentration were not studied. The test organisms were limited to five, while many others (including *Salmonella typhosa* and cysts of *Endameba histolytica*) would be of sanitary significance. The addition of spores of fungi to the series would have increased the scope of the data.

The results suggest that gamma irradiation can be used to destroy microorganisms in water and wastes. The same results would have been obtained if concentrated reactor wastes or a spent fuel element had been used instead of the cobalt-60 source. Although no immediate application is suggested, water and waste disinfection should be included in any comprehensive program in which studies are

* Roentgen equivalent, physical—a quantity of radiation which produces a specified amount of ionization in tissue.

made of potential uses of wastes from a large nuclear power industry.

Summary

Samples of double-distilled water and autoclaved sewage were inoculated with appreciable doses of *Bacillus subtilis, Mycobacterium smegmatus, Micrococcus pyogenes* var. *aureus, Esch. coli,* and *Esch. coli* phage T3 and exposed to gamma irradiation from a 1.1-kilocurie source of Co^{60}. Samples of settled sewage and sewage sludge were similarly irradiated.

TABLE 4

Cobalt-60 Gamma-Ray Dosage Required for 99 and 100 Per Cent Kill in Settled Sewage and Sewage Plant Sludge

Item	Dosage Required—*rad*	
	99% Kill	100% Kill
Settled sewage	1.2×10^5	5.0×10^5
Sludge, air dried	8.5×10^4	2.0×10^5

All of the test organisms, when suspended in distilled water and in sterilized sewage, were destroyed by gamma radiation. The dosage for complete kill was high, ranging from 2.0×10^6 rad for *Bacillus subtilis* to 7.5×10^4 rad for *Esch. coli* phage T3 when suspended in distilled water.

The samples of settled sewage and sewage sludge were sterilized by gamma irradiation. The dosages required for 100 per cent kill were 5.0×10^5 rad and 2.0×10^5 rad, respectively.

The dosage required for lower kills was materially less than for 100 per cent kill. With the exception of *Bacillus subtilis,* the most resistant of the test organisms, kills up to 90 per cent were achieved in water, settled sewage, and sewage sludge at dosages no larger than 7×10^4 rad.

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Measurement of Low-Level Radioactivity in Water

Lloyd R. Setter and Abraham S. Goldin

A paper presented on Dec. 15, 1955, under the sponsorship of AWWA, at the EJC Nuclear Eng. & Science Congress, Cleveland, Ohio, by Lloyd R. Setter, In Charge of Radiological Investigations, and Abraham S. Goldin, In Charge of Radiochemical Methods, both of the Radiological Health Program, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

DEVELOPMENTS in the useful application of nuclear energy and its byproducts have focused increasing attention upon the public health problems connected with the pollution of water by radioactive material. Liquid wastes from the operation of nuclear reactors, wastes from the uses of radioisotopes, and fallout from the detonation of nuclear weapons already have added quantities of radioactivity measurable above the natural or background radioactivity in water. The USPHS is collaborating with the AEC and other agencies in delineating the problems and assisting in their solution. One of the responsibilities of the Robert A. Taft Sanitary Engineering Center is to investigate and develop methods for the measurement of radioactivity in water, sewage, and industrial wastes. The purpose of this article is to describe one reliable method.

Permissible Radioactivity Levels

The levels at which radioactive materials in water may present a health hazard are extremely low. According to the National Committee on Radiation Protection (*1*), the maximum permissible concentration of radium-226 in drinking water is 40 micromicrocuries per liter ($\mu\mu$c/l), while for strontium-90 it is 800 $\mu\mu$c/l. These levels of radium and strontium radioactivity represent only 4×10^{-8} and 5×10^{-9} mg/l, respectively. For either alpha or beta activity of unknown source, the maximum permissible concentration is only 100 $\mu\mu$c/l, or 222 disintegrations per minute per liter.

The maximum permissible concentrations (MPC) of the most hazardous beta-emitting isotopes (*1*) are as follows (in μc/l): strontium-90 (including daughter product yttrium-90), 0.0008; iodine-131, 0.03; strontium-89, 0.07; copper-64, 0.1; phosphorus-32, 0.2; calcium-45, 0.5; argon-41, 0.5; and iridium-192, 0.9. Sometimes these concentrations must be modified to allow for possible damage to the digestive tract by radioactive materials which are not absorbed by the body (*2*). To detect possible increases in the radioactivity of waters at an early stage, methods of assay must be able to detect and to measure, with a fair degree of accuracy, levels well below the maximum permissible concentration.

Because of the wide range of maximum permissible concentrations, the hazard of contaminated water can be evaluated accurately only by determining the concentration of specific isotopes. In water contaminated with young mixed fission products, for ex-

ample, a very large portion of the total activity is caused by short-lived isotopes of low ingestion hazard, and a relatively high concentration of gross beta activity may, therefore, be tolerable. Thus, the AEC has stated (*3*) that a drinking water contaminated to 5 μc/l by 3-day-old mixed fission products would be safe for continued use. In such a water, although the gross radioactivity decreases rapidly, falling to 0.3 μc/l in 30 days, the change in the hazard is insignificant, as the more hazardous radioisotopes have slow decay rates.

Low-Level Counting

Although gamma radiation is much more penetrating than other forms, it is usually detected with low and variable efficiencies; furthermore, some important isotopes do not emit gamma radiation. Alpha radiation is entirely absorbed by less than 0.1 mm depth of water and (depending upon the energy) beta radiation is absorbed by 1 cm or less of water. As a consequence, it is necessary in low-level assays to circumvent water absorption by evaporating the water or removing the radioactivity by precipitation or comparable means. Even after the separation of the radioactivity from water by evaporation or precipitation, there remain sample solids which absorb radiation. To minimize this loss (self-absorption) the residues are deposited in thin layers for counting. The volume of the sample taken depends upon the radioactivity content, the solids content, and the area of the counting dish.

The small amount of radioactivity being measured makes it necessary to use an instrument which is highly efficient in detecting the radiations from the sample. This efficiency depends upon four factors:

1. *Geometry,* or that fraction of the radiation which shines into the sensitive volume of the detector
2. *Backscatter,* or that fraction of the radiation which is reflected into the sensitive volume of the detector
3. *Absorption,* or that fraction of the radiation which is absorbed before reaching the sensitive volume (includes self-absorption, window absorption, and air absorption)
4. *Counter efficiency,* or that fraction of radiation entering the sensitive volume which is counted.

It is obvious that the overall efficiency is greatest with high geometry, high backscatter, high counter efficiency, and low absorption losses. Each of these factors must be known in order to convert the results into curie values.

Instrumentation

A critical study of methods for low-level beta assay indicated disadvantages inherent in conventional end-window counting (*4*). These disadvantages were: [1] low and variable overall efficiency (5–10 per cent) in counting beta radiations (very low overall efficiency for beta activity of low energy); [2] variation of counter geometry as a result of difficulty in obtaining uniform deposition of radioactivity; and [3] high self-absorption losses for a given volume of sample. An additional instrument is required for assaying alpha activity, thus involving an important cost factor in small laboratories.

The method selected by the Radioactivity Investigations Unit of the Sanitary Engineering Center (*5*) utilizes an internal proportional counter which accepts dishes or planchets 2 in. in diameter with a maximum height of $\frac{3}{8}$ in. Compared to the end-window

counter, approximately 4 times as much sample volume can be used with the same self-absorption loss. Positioning and uniform deposition of the sample are less important, as the sample is placed within the counter chamber. The counter detects alpha radiations and all but extremely low-energy beta radiations. Excluding self-absorption, 50 per cent of the alpha, and about 65 per cent of the beta disintegrations are recorded. The efficiencies are lowered by self-absorption losses. For 2-year-old mixed fission product in 100 mg of sample solids, self-absorption reduces the beta efficiency from 65 to 48 per cent.

Alpha activity is counted, without beta interference, by adjusting the voltage to an appropriate level. Combined alpha and beta activity is counted at a voltage suitable for beta counting. Somewhat more than one count is recorded for each alpha particle, but, because the beta activity greatly exceeds the alpha activity, this apparent disadvantage is not usually serious.

The beta instrument background of the unshielded proportional counter varies from 50 to 65 counts per minute (cpm). During a single working day, the background rarely varies more than ± 5 per cent, which is within the expected statistical variation. Although the level of background is higher than that of shielded end-window counters, this disadvantage is of minor importance compared to the overall high detection efficiency of the internal proportional counter (*6, 7*).

Contamination of the counter chamber is rare, but, when it occurs (as evidenced by high background counts), it can readily be corrected by cleaning the chamber with a jet of clean compressed air, wiping with lens paper, or cleaning with a metal-polishing compound.

Preparation of Samples

Most of the studies of the Sanitary Engineering Center have been concerned with the uptake of radioactive wastes by sewage treatment processes, the chemical treatment of radioactive aircraft wastes, the distribution of radioactive rainout in surface waters, and amounts of natural radioactivity in surface and well waters. In each of these studies it has appeared desirable to differentiate between the insoluble and soluble radioactivity—that is, between that portion which is particulate or associated with particulate matter and is retained on molecular filter membranes and that portion which passes such filters. For this reason, the insoluble matter in an appropriate sample of 50–1,000 ml or more is collected on a filter disc which is then transferred to an aluminum dish (bottle cap) 48 mm in diameter. After drying and weighing, the sample is counted. Using this method, the insoluble activity of water samples can be ready for counting in less than 30 min. As a very high percentage of rainout radioactivity of young (1–10 day) fission product is removed by filtration, this single determination becomes a quick estimate of the magnitude of radioactive rainout.

The filtrate or soluble activity is determined by evaporating an appropriate sample volume (usually 250 ml), containing preferably less than 100 mg of solids, in a pyrex beaker. The residue is transferred to a weighed aluminum dish with the aid of a few drops of 1-*N* HCl and 10–15 ml distilled water, dried in an oven at 103°C, weighed, and counted.

Precision of Analysis

In assays of radioactivity in water and wastes, the precision of analysis is dependent upon the collection of rep-

resentative samples, the care taken in sample preparation, the variability of self-absorption losses as a result of variable radiation energy, and the reproducibility of counting random radioactive disintegrations. The latter (usually referred to as the "statistical error of counting") is important in deciding how long a sample should be counted to secure the desired degree of reproducibility of counting. For very low radioactivity levels, the counting error may be allowed to become a substantial fraction of the total error to secure speed of analysis. Ordinarily, at the Radioactivity Investigations Laboratory, the longest practical period for counting consists of two 16-min periods whose results agree within counting statistics.

As an example of the kind of precision attainable, replicate 250-ml samples of a cistern water were evaporated in 250-ml pyrex beakers. After the dry solids were transferred to counting dishes, the replicate beakers were washed with concentrated hydrochloric acid and rinsed with water to determine additional activity recoverable from the empty beakers. Similar replicate tests were made on a turbid rain water, and on a rain water containing settleable radioactivity. The results are presented in Table 1. The table shows that, for total and dissolved activity at a level of 700–1,000 $\mu\mu c/l$ of cistern water, the standard deviation was 17–30 $\mu\mu c/l$. The ratio of the standard deviation to the mean (coefficient of variation) was 2–4 per

TABLE 1

Precision of Radioactivity Analyses

Type of Sample	Sample No.	Beta Activity—$\mu\mu c/l$			Standard Deviation $\mu\mu c/l$	Coef. of Variation %	Error* %
		Min.	Max.	Mean			
Cistern water							
Suspended activity	1–5	117	158	134	20	15	8–11
Dissolved activity	1–5	713	781	746	30	4	3–6
Total activity	1–5	855	898	880	17	2	
Total activity	6–20	869	936	904	25	3	3–5
Total activity	1–20	855	936	898	21	2	
Acid wash†				4			
Turbid rain							
Coated beakers‡	21–26	1,830	2,330	2,047	175	8	4–5
Uncoated beakers	27–32	1,775	2,350	2,137	215	10	4–5
All beakers	21–32	1,775	2,350	2,092	194	9	4–5
Acid wash†				18			
Rain with sediment							
Radioactivity	33–38	14,300	19,600	16,800	2,075	12.3	
Acid wash†				30			
Radioactivity	33–38	43.7§	48.2§	45.7§	1.6§	3.5	1.8–2.1
Total solids	33–38	314‖	430‖	368‖	17‖	4.6	

* Statistical counting error at 95 per cent confidence level.
† Average activity recovered by concentrated HCl from empty beakers used for evaporations.
‡ Treated with water-repellent silicone compound.
§ In $\mu\mu c$/mg of solids.
‖ In ppm of total solids.

cent, as compared to the statistical counting error of 3–6 per cent at the 95 per cent confidence level. The analyses of the suspended radioactivity at a mean level of 134 $\mu\mu$c/l showed a similar standard deviation but a higher coefficient of variation (15 per cent). It is interesting to note that an average of 4 $\mu\mu$c/l or 0.5 per cent of the accountable radioactivity could be recovered from the empty beakers by a stringent acid wash.

The turbid rain water contained some organic floc which made representative sampling more difficult. Half of these samples were evaporated in pyrex beakers treated with a water-repellent silicone compound,* the remainder in untreated beakers. The silicone coating did not improve the recovery efficiency or the precision of the test. On the basis of the 12 turbid-water samples, the standard deviation for a mean of 2,092 $\mu\mu$c/l was 194, or a coefficient of variation of 9 per cent. Only 0.8 per cent of the accountable activity was recovered in the stringent acid wash.

Representative sampling of water containing settleable radioactive solids is more difficult. This is shown by the variable total solids from equal volumes of sample (250 ml). Consequently, the precision of the total solids (in parts per million) and the radioactivity per unit weight of solids, and per unit volume of water, were determined. The results of activity per milligram of solids show a smaller percentage of error (coefficient of variation of 3.5 per cent) than when based on the volume of sample (coefficient of variation of 12.3 per cent). Only 0.18 per cent of the accountable activity was recovered in the acid wash.

* Desicote, a product of Beckman Instrument Co., Fullerton, Calif., was used.

Discussion

The determination of gross alpha and beta activities at levels below the maximum permissible concentrations for the most hazardous isotopes is useful for pollution control purposes as well as for establishing background information.

Further analysis is required to evaluate the potential health significance of sustained levels of radioactivity near the maximum permissible levels. A rapid decay rate may establish the absence of significant quantities of the more hazardous long-lived emitters. On the other hand, the presence of substantial activity of long-lived isotopes will require more time-consuming analyses for such materials as radium-226 (*8*), total strontium (9) or strontium-90 (*10*).

Where waters are grossly contaminated, it will be necessary to determine the individual isotopes responsible for such contamination. The development of procedures for the determination of the more hazardous radioisotopes is currently under study.

Summary and Conclusions

The determination of the extent and significance of radioactive water pollution requires a prior knowledge of the natural radioactive background and the current levels of gross alpha and beta radioactivity as well as some knowledge of the source of contamination (with respect to the kinds of radioisotopes). Methods have been developed and surveys made on both natural background and artificial radioactivity (*11–24*). Some of the methods, though involved, have high specificity. Other methods are simple but less specific.

The gross alpha and beta measurements can be assayed at high overall efficiencies. Such a method for low-

level measurements has been described. The method is sensitive to 10–30 per cent of the maximum permissible concentration for unknown isotopes. With ancillary data on the kind of radioisotopes present, this measurement should be quite adequate for estimating the current hazards. Eventually, when the history of contamination becomes obscure or more uncertain, it will be necessary to develop accurate, discriminatory techniques for separately measuring the more hazardous radioisotopes. Studies in this direction are desirable. Fortunately, the more hazardous water contaminants deriving from nuclear-energy operations consist of only a few isotopes in mixed fission products such as strontium-90, strontium-89, and iodine-131. Further studies can be expected to evolve quantitative methods for assaying low levels of specific isotopes in wastes and waters for a more reliable interpretation of the overall significance of radioactive contamination.

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Application of Air Photo Interpretation in the Location of Ground Water

Robert H. L. Howe, Harvey R. Wilke, and Don E. Bloodgood

A revision of a paper originally presented on Feb. 12, 1953, at the Indiana Section Meeting, Indianapolis, Ind., by Robert H. L. Howe, Proj. Engr., Eli Lilly & Co., Lafayette, Ind.; and Harvey R. Wilke, Assoc. Prof. of San. Eng., and Don E. Bloodgood, Prof. of San. Eng., both of Purdue University, Lafayette, Ind.

THE technique of air photo interpretation has been employed for some time in the performance of soil surveys (*1*) and the analysis of soils and engineering materials (*2, 3*).

As reported in the literature, air photo studies have been used to determine the origin and nature of soils, kinds of rock, nature of the geologic structure, land use, drainage, and even certain hydrographic characteristics of an area (*4–7*).

Basically, the technique of interpreting air photos involves the recognition of various ground features and the logical deduction of their geologic and engineering significance. To study ground water locations, the analyst must also have a thorough background in geology, hydrology, geomorphology, and pedology. The work of the air photo analyst in appraising the geologic and engineering characteristics of an area might be compared to that of a doctor in interpreting an X-ray film to appraise the condition of a patient: a thorough background in physiology, biology, and bone structure is necessary to interpret and evaluate X-ray photographs properly.

Of the few tools used by the air photo analyst the most essential is the stereoscope, shown in Fig. 1. This simple instrument is much like that employed in a parlor pastime in the early 1900's, or the more modern devices used for viewing slides from stereoscopic cameras. When two air photos, taken from slightly different points, are viewed under the stereoscope, the terrain appears in three dimensions.

Air photo interpretation has been employed for highway, railway, and pipeline location, ground measurement, city planning, traffic control, mineral and petroleum prospecting (*8, 9*) and determining water depths along beaches (*10*).

Water Works Applications

To a water works man with a water supply problem, air photos might provide such valuable information about the nature of a watershed as the topographic features, slopes, general characteristics of soils, and land use. The use of air photos, for surface runoff estimation, is also considered feasible (*11*). Although only the ground surface is visible in an air photo, it is possible, through proper analysis and coordination with available data, to obtain considerable information about subsurface conditions. Air photo interpretation can, at best, merely assist in appraising ground water potentiali-

ties, and it is not intended that air photo interpretation should be considered as, of itself, a satisfactory method of locating a ground water supply.

By some, air photo interpretation might be taken to imply a "water-witching" job on a colossal scale. Kenneth Roberts has described Henry Gross employing his water-witching abilities over a map of Bermuda and thereby locating water (*12*). The technique which is discussed in this paper is not to be confused with procedures employing a willow stick or a welding rod. Air photo interpretation, like the doctor's interpretation of a chest radiograph, involves scientific procedures. Once such procedures have been mastered and can be applied by the analyst, he may be able to see on air photos things that can provide valuable ground water information.

Terrain Characteristics

The availability of ground water depends to a considerable extent upon the terrain characteristics, some of which can be evaluated from air photos. The patterns made by each "wrinkle" of the earth, the shapes of gullies, the patterns of streams and their tributaries, and the tonality of shading of the photograph, all provide valuable information for the interpreter, who is able to recognize the pattern features (*13*) and analyze and evaluate data obtained on various ground situations observed in the photographs.

The *vegetation* that is observed may be of value in interpreting the kind of soil, or, in some instances, the topography. Tonality or shading tones of the vegetation on airphotos may provide considerable information about the texture or moisture content of the soil.

The *use of the land* is a guide to the interpreter in determining soil types. The farming methods employed on flood plains will show definite contrast to those of upland farming areas.

The *topography* of the area—the size and location of hills and valleys, uplands and lowlands—is often indicative of soil types and geologic formations.

Drainage features exhibit very definite characteristics in certain types of soils and subsurface formations. These include: [1] the appearance of the cross section of a gully; [2] the gradient of the gully; and [3] the pattern of the drainage features. All of these help to identify types of soils and even the condition of the subsurface deposits.



Fig. 1. Air Photo Interpreter Using Simple Stereoscope

Special ground features, such as kames and eskers, terraces, alluvial plains, lake beds, and gravel pits, are recognizable on air photos and represent certain types of surface and subsurface materials.

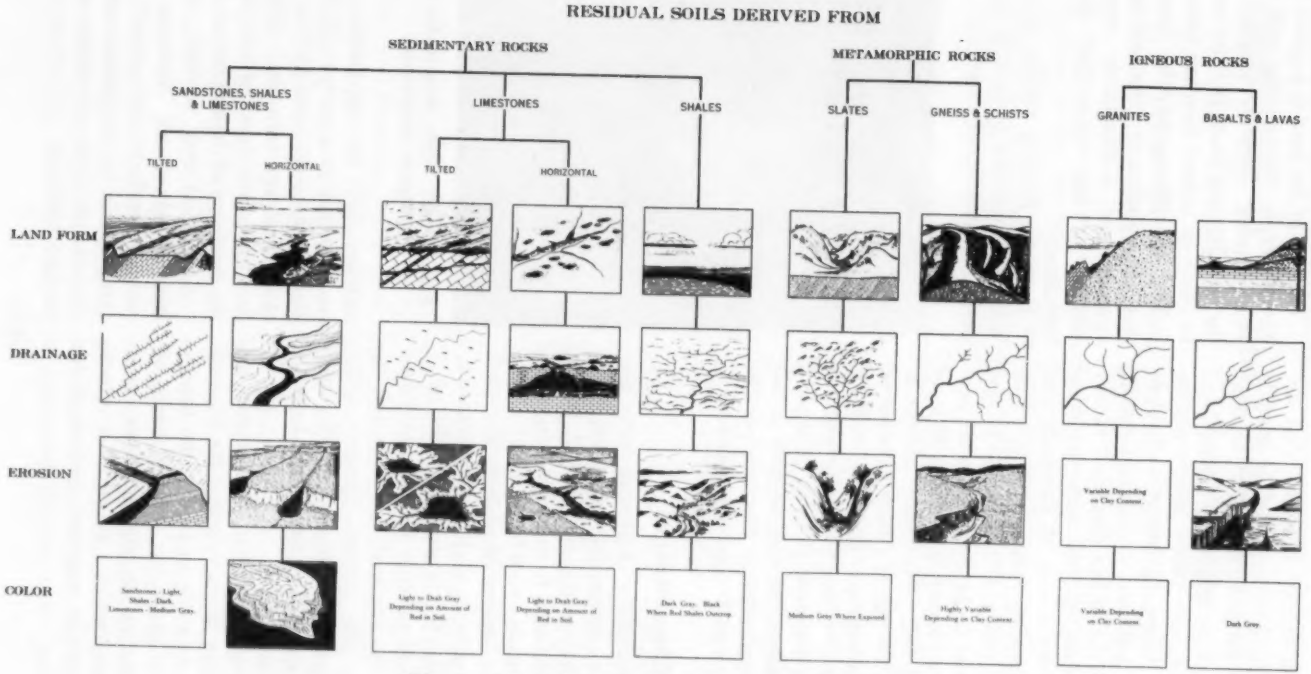


Fig. 2. Air Photo Analysis Chart—Residual Soils

Certain recognizable features on air photos, such as those illustrated in Fig. 2–4, can be used to identify kinds of soils and ground deposits. Engineering and agricultural soil maps can be prepared, and information concerning different soil areas derived from the proper interpretation of air photos.

Water-bearing Formations

The air photo analyst, besides being able to identify the textures of surface materials, can determine the nature of the deposits. Water-deposited materials, such as alluvium, outwash deposits, terraces, filled valleys, some types of kames and eskers, and resorted till plains, all yield specific patterns which are easily recognizable on air photos. Either the distinctly porous or distinctly impervious deposits can be predicted through air photo analysis.

Examples of procedures which are employed to locate ground water by air photo interpretation were included in an Indiana Department of Conservation research project established at Purdue University (*19*). Eight counties were studied, covering eleven subphysiographic and geological areas of Indiana (*14*).

The study made of Tippecanoe County is recorded here as an example. The ground water conditions were appraised and a map was made to indicate the ground water situation in the county.

Study of Tippecanoe County

Tippecanoe County was covered several times by glaciers, which left deposits of clay, silt, sand, gravel, and boulders (*15*). Beneath these glacial deposits is bedrock. The present topographic condition of the county is the result of glaciation and subsequent erosion (*15*). The average annual rainfall for the county is 38 in., which is rather uniformly distributed over the 12 months (*16*). Of this 38 in., about 72 per cent is lost through evaporation and transpiration (*14*). The remaining 28 per cent is runoff, of which one-third goes into the soil as ground water recharge, some of which later emerges as runoff. Corn, wheat, oats, soybeans, alfalfa, and clover are grown. Only a small portion of the county is heavily wooded.

Mosaic Map

After a literature survey was completed, an uncontrolled *mosaic map*, showing the general photographic appearance of the county, was assembled. A portion of this map is shown in Fig. 5. About 240 air photo contact prints were needed for Tippecanoe County. These, at a scale of 20,000:1, were obtained from the US Department of Agriculture at a cost of about 50 cents each. Thus, the pictures used for the mosaic map of Tippecanoe County cost the university $120.

Drainage Map

Following study of the mosaic map, a detailed stereoscopic study of individual photo pairs was made. From this study a drainage map was prepared, the surface materials outlined and appraised, the land form determined, land use observed, and special features noted.

The drainage map was prepared by marking the observed drainage features on the air photos and then transferring these markings to a map. A portion of the drainage map is shown in Fig. 6. The drainage systems were observed to be characteristic of the Wisconsin glacial drift: coarse textured (fewer lines or gullies per unit area) in the morainic areas, and medium-to-fine textured (more lines

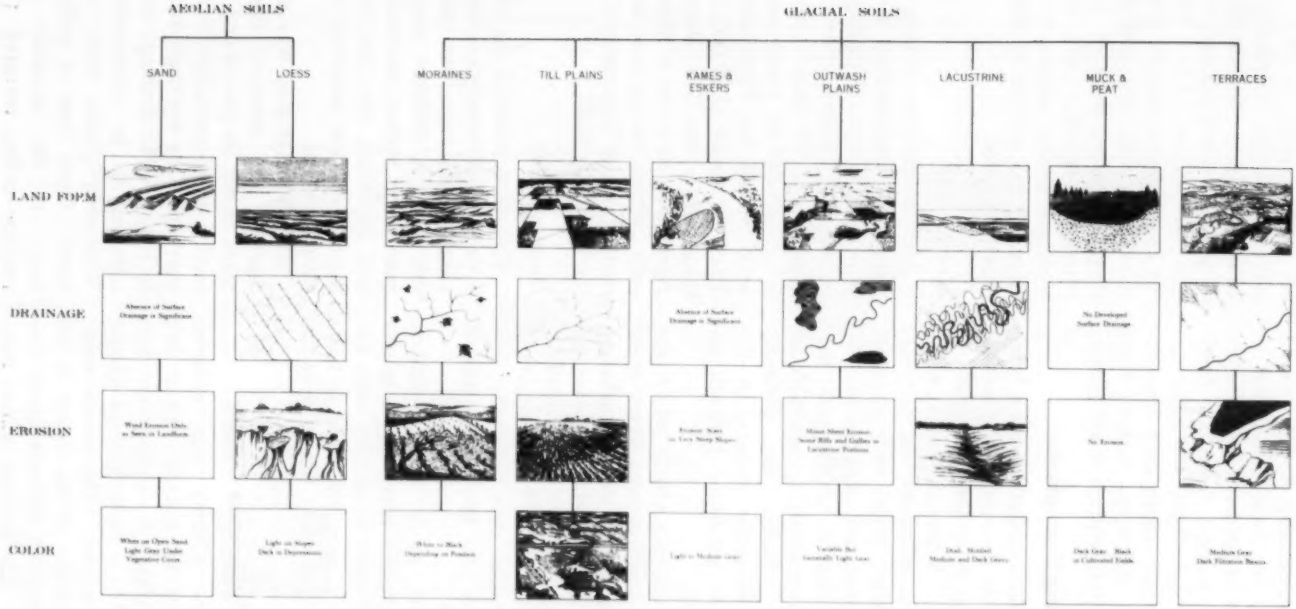


Fig. 3. Air Photo Analysis Chart—Glacial and Aeolian Soils

per unit area) in the till-plain areas. On the granular terraces along the streams there is an absence of surface drainage because the drainage is essentially internal.

Land Form Studies

The land form of Tippecanoe County was observed in three dimensions by use of the stereoscope. It was observed that the general ground surface along the major streams is broken and hilly. Many terraces and outwash plains were observed along the streams. By stereoscopic viewing of photo pairs it was possible to observe the flat areas of the terraces perched somewhat above the flood plain of the creek.

In some areas the tonality of the air photos of terraces and outwash areas was light, indicating that the water table was low or that little organic topsoil was present. Where the tonality is grey to dark the water level is higher, or some organic topsoil is present. In the morainic areas of Tippecanoe County the ridges are clearly defined under stereoscopic view. The kames and eskers in the southern part of the county show a somewhat light tonality.

Soils Map

A study of the air photos was made to determine the surface materials. The preparation of a surface-materials map was the next step in the study. Each of the different soil areas (water-deposited and ice-deposited) was outlined on the photos. After the soils had been identified for all parts of the county, a soils map (*see* Fig. 7) was prepared.

Several buried preglacial valleys are indicated in the literature. The air photo studies show the patterns of these buried channels, indicating in some areas the original valley-like topography, the chain-like elongated depressions, and the dark tonality caused by the high moisture content in the depressed areas (*17*). Gravel pits and white fringes of granular, well-drained soils along man-made ditches led to the obvious conclusion that water-bearing gravels were present. The identification of the old stream beds was thus indicated by the recognition of some features in aerial photos. Geologic literature, well drillings, and field investigation verified this interpretation. The locations of several granular deposits were in agreement with the previous work by Hittle (*18*).

Ground Water Map

A ground water prediction map was made. From the air photo studies, unconsolidated granular and potential water-bearing formations (by virtue of the low elevations, erosional features, drainage patterns, tone, and vegetation) in Tippecanoe County were observed in stream terraces, outwash plains and alluvial plains. Locations of these features were outlined on the air photos and then transferred to the ground water map, a portion of which is shown in Fig. 8.

Class A areas were established by the location of granular deposits in stream terraces, alluvial plains, outwash plains, glacial sluiceways, and filled valleys. Such deposits, located at a low ground elevation, are recognized on air photos by their granular characteristics and the absence of natural drainage channels. Wells in the Class A areas were evaluated and were found to be able to produce more than 200 gpm.

Class B areas were established by the location of morainal deposits, eskers, and kames. Because of the relatively small deposits of these materials,

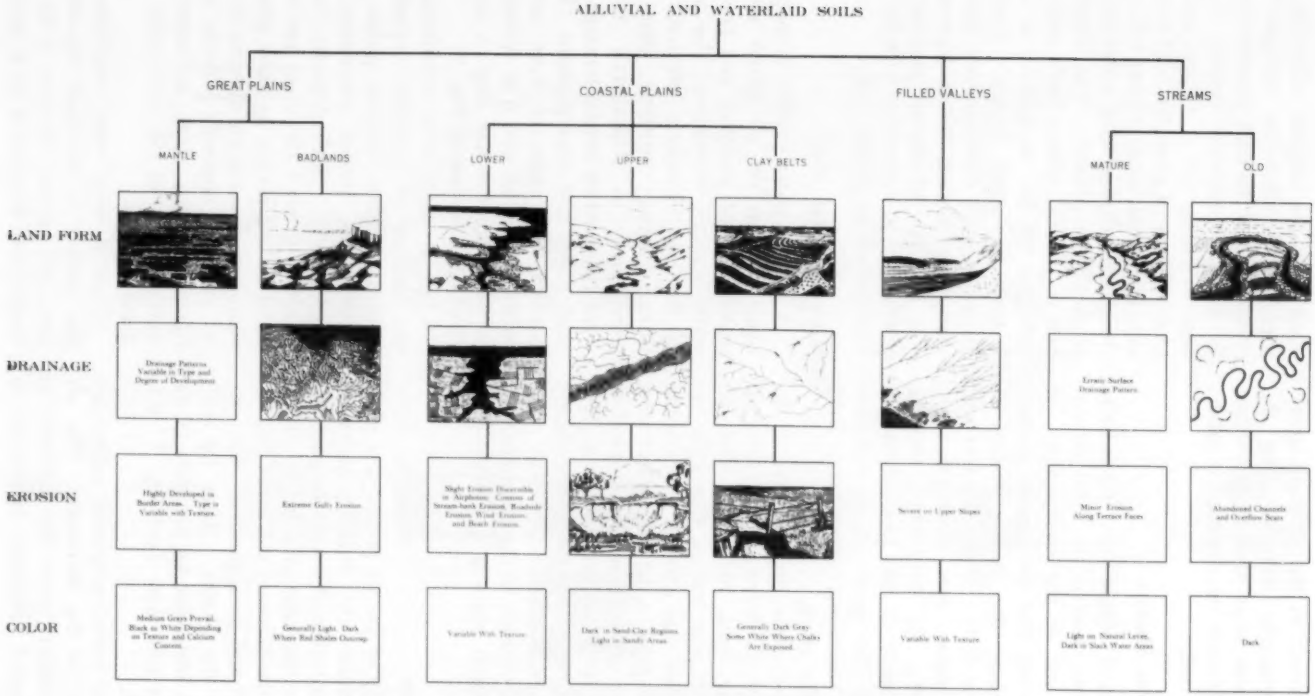


Fig. 4. Air Photo Analysis Chart—Alluvial and Waterlaid Soils

however, and the fact that many of them occur at higher elevations, they cannot be expected to retain appreciable quantities of water. Wells in these areas were found to be able to provide sufficient water for farms and household uses only.

Class C areas are on the upland till plains where granular deposits are few, and where there may be found organic topsoils that generally do not permit surface water to penetrate into the ground. Although occasional granular deposits may be anticipated at certain depths below the ground surface, such granular deposits are generally scattered, small, and thin. Class C areas were therefore found to possess an uncertain or poor water yield potentiality. The check wells in the C areas were found to satisfy only the minimum requirements for household uses.

The ground water predictions were checked against well records, and some areas had to be redefined. At the time of this research there were available 62 well logs which supplied data upon the quantity of water produced from each of the wells.

Of the 62 wells, 31 are located in Class A areas (alluvial area terraces, filled valleys, outwash areas, and sluiceways). All 31 are reported to give a "good" water supply. Lafayette municipal wells, which were found to be in this Class A area, produce around 2,000 gpm. The Eli Lilly & Company well, also in a Class A area, produces more than 4,000 gpm.

There are 27 wells in the Class B areas (drift and morainic areas), reported to yield "fair" quantities of water. One well in this group is reported to produce about 150 gpm.



Fig. 5. Portion of Air Photo Mosaic, Tippecanoe County, Ind.

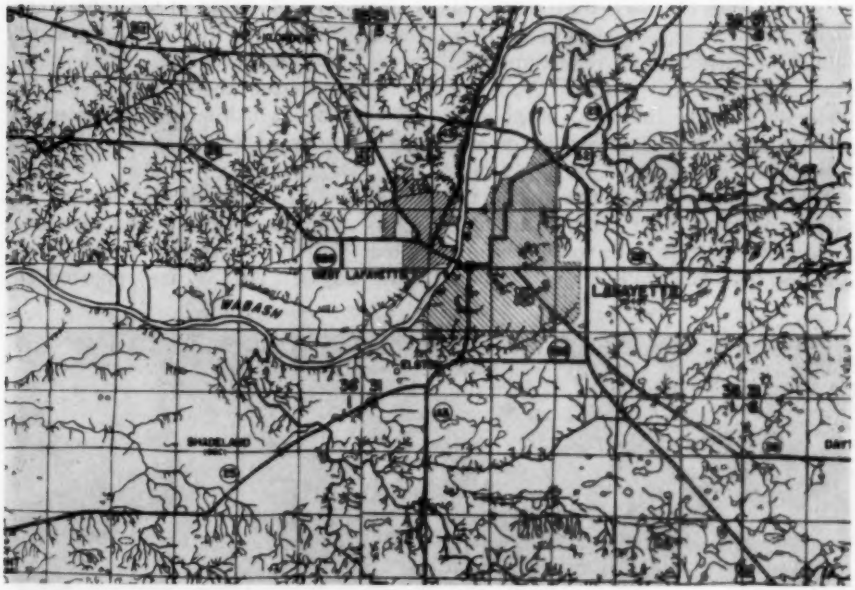


Fig. 6. Portion of Drainage Map, Tippecanoe County, Ind.

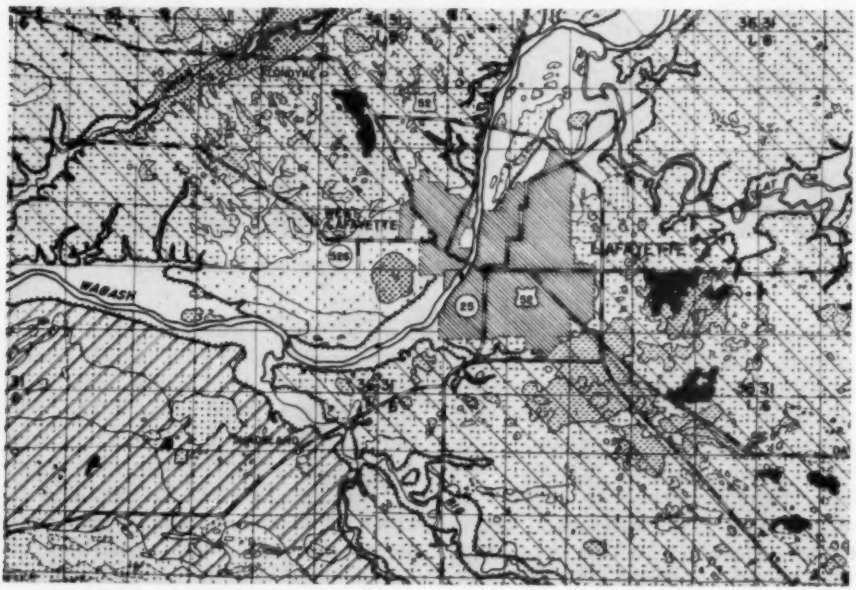


Fig. 7. Portion of Engineering Soils Map, Tippecanoe County, Ind.

Only four of the 62 wells are in the Class C area, and they are represented as "poor" in water supply.

Summary

As a result of the air photo studies in Tippecanoe County, it is indicated that water-bearing formations such as alluvial plains, terraces, outwash deposits, granular morainal areas, and sandy lake beds can be located by the aid of aerial photographs. These areas are potential sources of ground water.

The regional ground water maps demonstrate the general ground water conditions in an area, thus indicating the areas most (and least) promising for water prospecting. Such maps suggest the location of test well sites, thereby reducing the cost of prospecting. Regional ground water maps may be very useful and money-saving in the selection of potential plant sites.

Conclusions

1. Air photos can be helpful in the prediction of the ground water conditions of an area and can assist materially in locating sites for test wells.

2. These studies should be continued and perfected, in order that the degree of accuracy of prediction be determined.

3. Air photos provide an inexpensive method for indicating the availability of ground water through the identification and location of water-bearing sands and gravels located in buried valleys, terraces, sandy lake beds, alluvial plains, and outwashes.

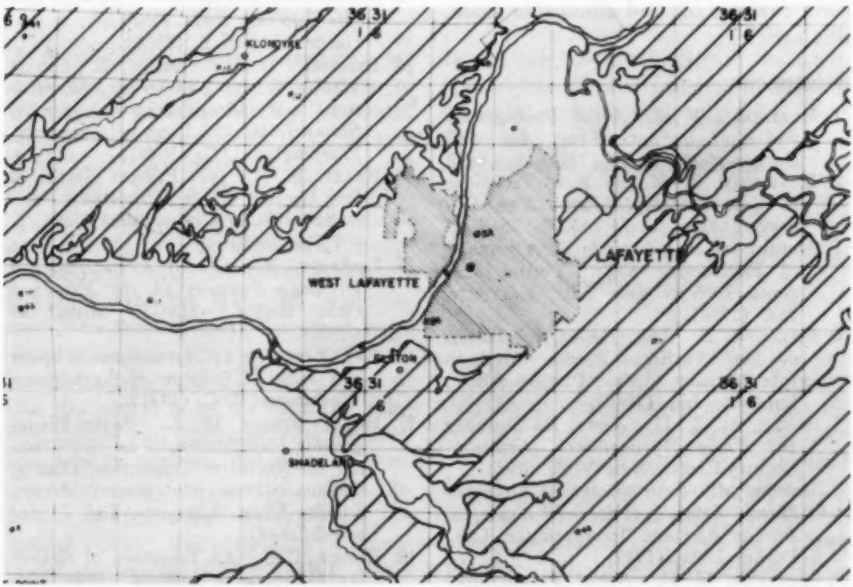


Fig. 8. Portion of Ground Water Map, Tippecanoe County, Ind.

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Use of Molecular Filter Membranes for Water Potability Control

Harold A. Thomas Jr., Richard L. Woodward, and Paul W. Kabler

A contribution to the Journal by Harold A. Thomas, Jr., Prof. of San. Eng., Div. of Eng. and Applied Physics, Harvard Univ., Cambridge, Mass.; Richard L. Woodward, Sr. San. Engr., and Paul W. Kabler, Chief of Microbiology, both of Robert A. Taft. San. Eng. Center, Cincinnati, Ohio.

MEMBRANE filter techniques for the quantitative estimation of coliform organism density in water supplies and waste water disposal systems have been developed intensively during the past 5 years. The results obtained from a wide variety of natural and treated waters show that membrane filter techniques have several advantages over the standard fermentation tube method. At the same time, certain limitations in the new technique have become evident. The purpose of this discussion is to consider the relative merits and limitations of the new tool and to evaluate its utility in routine bacteriological control. The objective is approached by analyzing the quality control characteristics of a proposed molecular filter (MF) membrane coliform organism standard for potable water designed approximately to parallel the USPHS standard (*1*) based on the fermentation tube method.

The conclusion is reached that the advantages of the MF method impressively outweigh the disadvantages and that, in the present stage of development, certain MF techniques may profitably be used in regulatory coliform organism determinations. Adoption of the MF procedure as an acceptable alternate to the standard fermentation tube test would permit the widespread use of this important advance in water examination technique.

Advantages and Limitations

The salient points relating to the merits of MF techniques and the standard dilution (MPN) procedure may be outlined as follows:

Advantages

1. Larger volumes of treated water may be processed when membrane filters are used. A long-standing source of dissatisfaction with the standard 10-ml tube test stems from its inability to give a precise indication of coliform organism densities of less than about 1.0 per 100 ml. With larger, more representative samples, the MF test may be made to work at low-density levels and thereby provide valuable information for plant control.

2. Filtration may be carried out in the field, thus eliminating the difficulty and expense of shipping liquid samples. Field filtration of the sample and shipment of the filters to a laboratory on a preservative medium at ambient temperatures gives about the same results as a standard MPN test on refrigerated samples examined after 24

hr. The results are better than those from fermentation tube tests made on unrefrigerated samples stored for 24 hr or longer. For shipped membranes, holding periods of as long as 72 hr apparently allow for recovery of most coliform organisms (*2*).

3. The values obtained with membrane filters are from two to five times more precise than those obtained with the standard dilution method under comparable conditions of testing. The improved reproducibility is caused by the fact that a filter provides an integral number (the number of sheen colonies), where a fermentation tube inherently can only indicate the presence or absence of coliform organisms in the inoculum. The increased precision is a significant advantage of the new technique. In water quality control it means that more information is obtained from each sample collected. With MF procedures, this gain may be taken in the form of a reduction in the number of samples processed or, with the same sampling frequency, in an improved knowledge of actual bacterial density trends and fluctuations in the supply.

4. With the MF techniques that have been investigated (*3–6*), the results are obtained in a shorter time than with the MPN method. The MF procedures require less than 24 hr to obtain results, while the fermentation tube tests require a minimum of 48 hr to obtain a negative result and may require as much as 6 days for a completed test. This important gain, however, is not achieved without loss, for it appears that the reduction in the processing time, which is obtained by a curtailment or elimination of the incubation period in enrichment media, is accompanied in some waters by a decrease in the efficiency of coliform recovery. It is in this aspect of the new procedures that the principal disadvantages arise, and it is in the establishment of an optimum balance between the duration of the tests and the efficiency of recovery that further work on MF techniques appears to be fruitful.

5. The MF technique requires less medium, incubator space, dishwashing, sterilization, and other processes, saving time and space in the laboratory. Portable laboratories for use of the membrane filter in the field can be devised, permitting examinations for coliform organisms to be made quickly.

Disadvantages

1. The coliform organism density estimates obtained using the MF techniques are generally less than those obtained by the standard MPN method. The difference in density estimates is partly, but not entirely, attributable to the mathematical bias of the MPN. Typical results of parallel testing, showing the effect of MPN bias, will be discussed in a subsequent section of this article.

In some waters, the ratio of MF estimates to MPN estimates of coliform density appears to be quite low. These discrepancies may be caused by specific characteristics of microorganisms in the sample, inhibitory action of growth medium, or peculiarities of the water examined. Shipe and Fields (*7*) have shown that excessive concentrations of copper and zinc salts in water may cause MF coliform organism results to be considerably lower than agar plate counts. It is possible that other materials may interfere. From an overall survey of parallel tests to date, however, it would appear that it is not common for interfering substances in the water to result in a substantial decrease in the relative efficiency of MF tests.

In some low-density waters the MF procedures have been found to yield higher recoveries than the MPN methods, despite the short periods of enrichment. This is illustrated in Fig. 1. High relative recovery in these cases may be attributed in part to the preference shown by many varieties of *Escherichia* and *Aerobacter* species for growth on moist surfaces rather than in the free-floating state.

2. In waters containing unusually large amounts of algae or other coarse particulate material, clogging of membranes may preclude the testing of samples sufficiently large to provide a reliable indication of coliform organism density. In certain other waters with very large ratios of noncoliform to coliform organisms, crowding of colonies may interfere with differentiation of coliform organisms. In highly turbid waters, clogging of filters may limit their usefulness.

3. Variations in the ability of individuals to recognize or distinguish the characteristic sheen production of coliform organisms may cause variations in results.

4. The current price of the filter disc makes the MF procedure somewhat more expensive than the standard method for negative tests when material costs are compared. This initial cost differential is narrowed when significant numbers of samples require confirmed and completed tests.*

* A number of estimates have been made of cooperative costs of water examinations by the MF and MPN methods. The difficulties with these lie in the assumptions made with regard to the percentage of samples requiring confirmation or completion, the time required for examination, and the labor costs involved. As any estimate would be no better than the assumptions on these factors, and as these can vary widely, there is reluctance to publish such estimates.

Some of these disadvantages can be overcome quite easily. The cost of the membranes should decrease as they become more commonly used. Moreover, the shorter technician time per test with the MF procedure actually results in an overall cost reduction. The skill of individuals in differentiating coliform organism characteristics will improve with training and experience.

Some of the disadvantages probably will not be overcome entirely. It is unlikely that the MF technique can or should replace the standard method in all water examinations. It does appear likely, however, that its advantages will lead to adoption in the many instances where its merits have been demonstrated. It is desirable, therefore, to study the relative efficiency of the two techniques in order to be able to devise standards for the membrane filter that will be equivalent to the widely accepted USPHS standards based on the MPN method (*1*).

Recovery Efficiency

The coliform group of organisms is a group with similar morphological and biochemical characteristics. It is a group by definition. As normally determined by the confirmed test outlined in *Standard Methods* (*6*), certain organisms or combinations of organisms found in water will give false positive tests. Because of overgrowth of coliforms by other organisms or inhibition of growth of coliform organisms by toxic substances, however, false negative results may be obtained. This is observed more frequently in examination of fluids other than potable water, but the phenomenon is well known.

The false positives are eliminated by the completed test, which is not usually performed in routine water exami-

nation. The completed test can give estimates of coliform organisms no higher than those obtained by the confirmed test. In certain waters, the results may be lower by as much as a factor of 10, following elimination of false positives. Therefore, even though the MPN method has been adopted and universally used, it is subject to certain inaccuracies and should be considered only as an index of the number of coliform organisms present. In addition to the above biological factors which contribute to its inaccuracy, there is a purely mathematical source of inaccuracy which is inherent in the MPN estimate of coliform organism density. This estimate, like many other maximum-likelihood estimates used in mathematical statistics, is biased and overestimates the true density (*8*). To render these estimates comparable with results from plates, filters, or direct-count methods, a bias correction should be applied. The amount of the correction depends on the number of tubes used in each dilution and decreases as the number of tubes increases. The situation is analogous to that in which an observer is comparing the readings of two thermometers, one at eye level, the other high on the wall. Because of parallax, the reading of the latter will be too large and must be corrected in order for the comparison to be valid. It is also analogous to measuring distances with a yardstick which is actually only 2 ft.

In a survey of three extensive comparative investigations (*9*), it was found that the densities obtained by MF methods averaged about 70 per cent of the confirmed MPN values. When the MPN measurements were adjusted for bias, however, the average recovery factor increased to 87 per cent. In these tests, the MPNs were determined from five fermentation tubes for each of three decimal dilutions; the appropriate factor for correction for bias is 81 per cent (0.81 = 1/1.23; the arithmetic mean of a large number of replicate 5-5-5 MPNs exceeds the true density by 23 per cent).

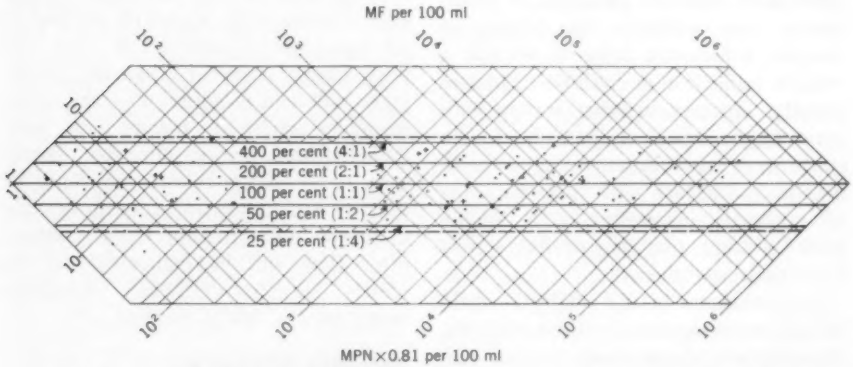


Fig. 1. Correlation Plot of Coliform Densities Obtained by Standard Method and MF Method

The black dots indicate data obtained at Woods Hole, Mass., from three ocean water-sampling stations. The crosses indicate data obtained from a group of streams and ponds near Boston. The data shown were reported by Thomas and Woodward (9).

Figure 1 is a correlation diagram of the coliform organism densities obtained in two of the investigations. Descriptions of the techniques used in these have been given by Yee and associates (*3*) and by Presnell and associates (*10*). Additional results of statistical analysis have been summarized by Thomas and Woodward (*9*). The dotted points pertain to data obtained at Woods Hole, Mass., from three ocean water–sampling stations; the crossed points represent results from a group of streams and ponds near Boston. In this latter series, each plotted point indicates the adjusted means of ten 5-5-5 MPNs and the mean count of 25 membrane filters.

The plotted points in Fig. 1 exhibit a fairly symmetrical dispersion about the central horizontal line (MF/0.81 MPN = 1.0), and indicates that in these two investigations the overall coliform organism recovery efficiency was approximately the same for the two procedures.

The relative recovery factors for individual samples vary from less than 25 per cent (1:4) to more than 400 per cent (4:1). From this wide range of observed relative densities, it might be inferred that the two techniques do not measure precisely the same types of coliform organisms. Such an interpretation, however, is not necessarily correct. It may be shown both experimentally and theoretically that a dispersion of points equal to or greater than that of Fig. 1 would be expected in a correlation diagram in which each point represented a pair of MPN values obtained from a single sample. The dashed parallel lines on Fig. 1 include a zone in which 95 per cent of the points obtained from duplicate fermentation tube tests may be expected to fall. The lines were constructed using the Halverson-Ziegler theory of dispersion of replicate MPNs (*8*). In Fig. 1, in which MF is plotted against MPN, 132 of the 139 points (94.97 per cent) for the Woods Hole series fall within the 95 per cent zone. Therefore, the implication for this series is that the correlation between the two methods is about the same as that which would be obtained between duplicate MPN values. Similar conclusions may be drawn from the data of other investigators, and it would appear that the large ranges in relative recovery factors that have been reported in certain types of water are caused mostly by the low reproducibility of the MPN test rather than to inherent differences in sensitivity of the two methods for various coliform bacteria. From statistical analysis not much support can be given to the assertion that the two methods have different selectivity for particular coliform strains.

Proposed Coliform Standard

A quantitative drinking water coliform standard, proposed for use with the tentative membrane filter techniques described in *Standard Methods* (*6*), is given in Table 1. The wording has been arranged to parallel the quantitative features pertaining to permissible coliform level of the USPHS standards (*1*); for ease of reference these standards for 10-ml fermentation tubes have been included in Table 1. Other sections of the *Standard Methods* (*6*) relating to sampling frequency should continue to apply with membrane filter techniques.

In their present form, the USPHS standards establish two distinct types of control. The first type (1a and 1b in Table 1) imposes a limitation upon the general level of coliform organism density as determined by average conditions prevailing on the watershed and

distribution system and by the type of supply and treatment. In an approximate way these paragraphs of the USPHS standards are devised to detect and prevent sustained coliform organism densities in excess of two or three organisms per 100 ml. The results of a sampling program which de-

TABLE 1

USPHS Drinking Water Coliform Code and Proposed Code Using MF Techniques

*Drinking Water Standards (1)**	Proposed MF Standards
Monthly Reporting Periods	
1a. Of all the standard 10-ml portions examined per month in accordance with the specified procedure, not more than 10 per cent shall show the presence of the coliform organism group.	1a′. A standard sample shall consist of not less than 50 ml, which shall be filtered through one or more membranes so that the total colony count (coliform plus noncoliform organisms) on each filter shall not exceed 400. The arithmetic mean density of coliform organisms of all standard samples examined per month shall not exceed 1 organism per 100 ml. The use of standard samples larger than 50 ml will provide more information than smaller samples, but the total colony count per filter shall not in any case exceed 400.
1b. Occasionally three or more of the five equal 10-ml portions, constituting a single standard sample, may show the presence of organisms of the coliform group, provided that this shall not be allowable if it occurs in consecutive samples or in more than: (a) 5 per cent of the standard samples when twenty or more samples have been examined per month (b) one standard sample when less than twenty samples have been examined per month.	1b′. Greater-than-average numbers of coliform organism colonies may occasionally be found in a single standard sample. This shall be permissible, provided the numbers of coliform organism colonies per standard sample are no greater than: 3 per 50-ml standard sample 4 per 100-ml standard sample 7 per 200-ml standard sample 13 per 500-ml standard sample, and 22 per 1,000-ml standard sample (a) any two consecutive standard samples (b) more than 5 per cent of the standard samples when twenty or more samples have been examined per month (c) one standard sample when less than twenty samples have been examined per month.
Daily Reporting Period	
2. When three or more of the five equal 10-ml portions constituting a single standard sample show the presence of organisms of the coliform group,† daily samples from the same sampling point shall be collected promptly and examined until the results from at least two consecutive samples show the water to be of satisfactory quality.	2′. When one standard sample shows a larger number of colonies than is permissible under Section 1b′,‡ daily samples from the same sampling point shall be collected and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

* See Sections 3.21 and 3.22, *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes (1)*.

† When this occurs, or when waters of unknown quality are being examined, simultaneous tests should be made on multiple portions of a geometric series ranging from 10 to 0.1 ml or less.

‡ When this occurs, or when waters of unknown quality are being examined, additional filtrations should be made on volumes ranging downward from the size of the standard sample.

termines whether or not a supply is conforming to the standards furnish valuable information regarding the overall suitability of the source of water and the adequacy of existing arrangements for collection, treatment, and distribution.

In the administration of the USPHS standards, it is understood that both requirements (Table 1, Sec. 1a and 1b) must be met for any monthly series of samples. This stipulation applies also to the proposed membrane filter code.

The second type of control (Table 1, Sec. 2) is designed to protect against daily contingencies, such as the failure of disinfection equipment or chance contamination—that is, back-siphonage in crossconnections. In an approximate way, Sec. 2 insures quick detection of coliform densities of ten or more organisms per 100 ml.

The USPHS standards are sometimes interpreted as promulgating a limiting density of one coliform organism per 100 ml. The mean density actually permitted is somewhat larger, however. It is true that the MPN of a set of 10-ml tubes showing 10 per cent positive results is 1.05 coliform organism per 100 ml, but, when the requirement of Sec. 1b, permitting occasional increases in density, is jointly taken into consideration, together with the bias of the MPN estimator, it may be shown that a water supply which just meets the USPHS standards would have a density of about 1.4 coliform organisms per 100 ml as obtained by averaging the MPNs of a long series of standard samples (*11, 12*). Mathematical proof of this statement will be found in Paragraphs 1 and 2 of Appendix A.

In setting the average density for membrane filter techniques at 1.0 organism per 100 ml (Table 1, Sec. 1a′), an allowance is hereby made for a lower MF coliform organism recovery in the approximate amount of 71 per cent (100/1.4) of corresponding MPN densities. An analysis of the literature of comparative investigations shows that this allowance is satisfactory for most waters.

Sections 1b and 2 of Table 1 are included in the USPHS standards in cognizance of the fact that water of potable quality may occasionally yield high-density samples because of random fluctuations above the mean level. In effect, this requirement places a definite limit on the frequency of density "overruns." Accordingly, the proposed code (Sec. 1b′ and 2′ of Table 1) has been designed to allow the same magnitude and frequency of sporadic fluctuations.

Quality Control

The USPHS standards have been evolved over a period of several decades and, with successive modifications, have achieved a remarkable utility in sustaining the requirements of public health with due regard to the practical exigencies of water supply control. Therefore, in the design of an alternate code for a new analytical tool, it is in the public interest to insure that an equal degree of health protection is afforded and also that substantial practical improvements are obtained.

In assessing the relative merits of the proposed standard, it is pertinent to compare it with the USPHS standards first in respect to long-term control (monthly and yearly reporting periods) as governed by Sec. 1a and 1b of Table 1, and, secondly, with daily or sample-wise control relative to contingencies affecting the safety of supplies as governed by Sec. 2.

With regard to long-term control, computations will show that for a

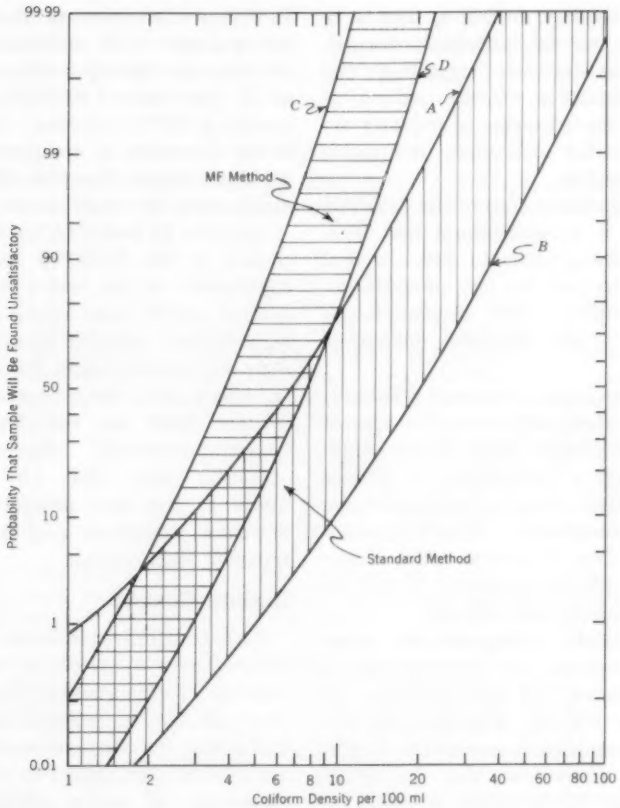


Fig. 2. Quality Control Characteristics of Standard Test and MF Test, Using 200-ml Samples

The horizontally sectioned area indicates data from MF method; vertically sectioned area indicates data from standard method. Curve A *indicates the probability that three or more of five 10-ml tubes of the standard set will be positive at the various levels; Curve* B *indicates the probability that all tubes will be positive. Curves* C *and* D *are for data from the MF test, with 200-ml filtrations and a rejection criterion of 80 or more colonies. Curve* C *is predicated on a coliform recovery efficiency for MF equal to that of the MPN test; for Curve* D *a 50 per cent of MF relative to MPN recovery is assumed.*

water supply just meeting requirements 1a and 1b there is a 95 per cent probability that the average MPN of 300 standard sets of five 10-ml tubes—representing, for instance, the results of a 12-month series—will fall between 76 and 124 per cent of the true population mean MPN (1.4 per 100 ml). The corresponding limits for the MF technique, entailing 300 standard samples of 200 ml each, are 85 and 117 per cent of the population mean density (1.0 per 100 ml). The narrower zone of sampling error obtained with filters indicates quantitatively the advantage of their superior reproducibility. From a practical viewpoint, the new techniques make it possible to follow

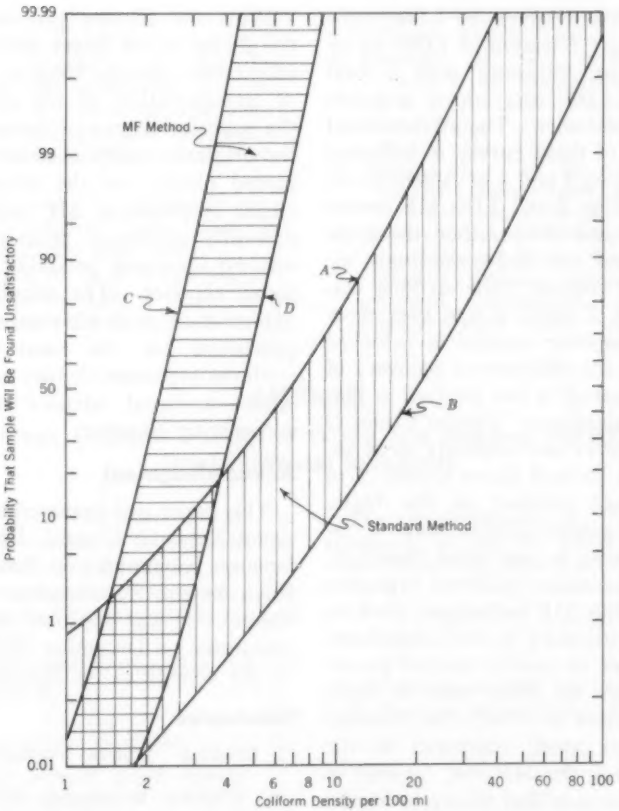


Fig. 3. Quality Control Characteristics of Standard Test and MF Test, Using 1-liter Sample

The lettered curves indicate the same as in Fig. 2.

density trends more precisely and to detect significant fluctuations more rapidly.

The control characteristics of the two methods with respect to daily or sample-wise operation are exhibited in Fig. 2 and 3. In this type of control it is essential that the test be sensitive in detecting surges in the density, particularly if these surges are large. Curves *A* and *B* of Fig. 2 indicate the sensitivity of standard fermentation tube tests in the detection of various coliform organism densities. Curve *A* gives the probability that three or more of five 10-ml tubes of the standard set will be positive at the different levels; Curve *B* indicates the probability that all tubes will be positive. In both cases the probability is low when the density is near unity and high when the density exceeds 20 organisms per 100 ml. Curves *C* and *D* of Fig. 2 pertain to the MF method with 200-ml filtrations and a rejection criterion of 8 or more colonies. Curve C is predicated on a coliform organism recovery efficiency for filters equal to that of the MPN tests; in Curve *D* a 50 per cent relative recovery is assumed. Figure

3 shows similar curves for 1-liter samples (a single filtration of 1,000 ml or two or more filtrations with a total volume of 1,000 ml) and a rejection level of 23 colonies. The mathematical derivation of these curves is indicated in Paragraphs 3 and 4 of Appendix A.

In both Fig. 2 and 3 the MF curves are higher and steeper than those for the standard test and accordingly afford better control. The striking feature of Fig. 2 and 3 is that they show that this superior control is achieved even when the efficiency of recovery of the MF method is low relative to that of the standard test. Curves *C* and *D* in both figures are relatively close together and lie well above Curve *A* of the standard method in the high–coliform organism density zones of interest. It may be concluded, therefore, that the diminished coliform organism recovery with MF techniques cited by some investigators is not significant with respect to quality control procedures. Even for those types of water and techniques in which the recovery is unusually small compared to the standard test, the MF test, because of its high precision and ability to handle large sample volumes, can, with a properly designed code of procedure, be made to give a better degree of quality control than the standard test.

Summary

An investigation of a proposed MF coliform organisms standard for potable water shows that the MF method has decisive advantages over the standard method using the fermentation tube. It is true that in the present stage of development, the efficiency of recovery of coliform organism on the membrane filter may be less in some waters than that of the standard fermentation tube method. The analysis indicates, however, that this disadvantage is more than balanced by the gains achieved.

With the shorter processing time, the ability to test larger and more representative sample volumes, the ease of transportation of filtered samples, the superior degree of preservation of the original density obtained on transported filters, and the substantial increase in precision, MF techniques as presently developed provide opportunity for improved potability control of water supplies. The adoption of the MF method as an alternative standard procedure for the measurement of coliform organism density would constitute a signal advance in sanitary engineering practice.

Acknowledgment

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APPENDIX

Mean Coliform Density of Water Just Meeting USPHS Drinking-Water Standards

Thomas (*11*) has shown that the gamma distribution is a suitable frequency distribution for fitting data on bacterial densities in water supplies. The notation used by Thomas will be used in this appendix.

The gamma distribution has the following equation:

$$f(\lambda) = \frac{a^{p+1}}{p!} e^{-a\lambda}\lambda^{p} \ldots\ldots (1)$$

Where $f(\lambda)$ is the relative frequency corresponding to a bacterial density, λ, and a and p are parameters of the distribution related to the mean value of λ by $\bar{\lambda} = \frac{p+1}{a}$.

In the standard fermentation tube test the probability of x positive tubes in a single-dilution five-tube test is:

$$P(x) = \frac{a^{p+1}}{p!}\frac{1}{5}\binom{5}{x}\int_0^{\infty}\lambda^{p}(1-e^{-\lambda})^{x} \times e^{-[(5-x)+a]\lambda}d\lambda \ldots (2)$$

For example, for $x = 3$ (three out of five tubes positive):

$$P(3) = 10a^{\bar{\lambda}a}\left[\frac{1}{(2+a)^{\bar{\lambda}a}} - \frac{3}{(3+a)^{\bar{\lambda}a}} + \frac{3}{(4+a)^{\bar{\lambda}a}} - \frac{1}{(5+a)^{\bar{\lambda}a}}\right] \ldots (3)$$

The requirements of the USPHS standard (*1*) can be written (for not more than 10 per cent of tubes positive):

$$0.1 \geq \sum_{x=0}^{5} x\,P(x) \ldots\ldots (4)$$

Or (for not more than 5 per cent of tests, with three or more tubes positive):

$$0.05 \geq \sum_{x=3}^{5} P(x) \ldots\ldots (5)$$

In the limiting case of a water just meeting the standards, Eq 4 and 5, provide two equations which can be solved for the two parameters of the gamma distribution. These parameters are: $a = 3.3$, and $p + 1 = 0.398$; or:

$$\bar{\lambda} = 0.121 \text{ per } 10 \text{ ml} = 1.21 \text{ per } 100 \text{ ml} \ldots (6)$$

That is, the above two requirements of the USPHS standards would just be met by a water with a mean coliform density of 1.21 per 100 ml.

Mean Value of MPN

To determine the mean value of the MPN for such a water, some assumption must be made as to the MPN to be attributed to the tests in which all tubes are positive. If one assumes an MPN

of 16.1 for such a result—that is, the same MPN as for four out of five tubes positive—the average MPN is:

$$E(\text{MPN}) = 0P(0) + 2.2P(1) + 5.1P(2) + 9.2P(3) + 16.1[P(4) + P(5)] = 1.4 \text{ per 100 ml} \quad (7)$$

Any other plausible assumption would lead to higher results.

Thus, if the MF method gives a recovery relative to the MPN method of $\frac{1}{1.4} = 0.71$, a standard limiting the average MF count to 1 per 100 ml would be comparable to the present standards for fermentation tube tests.

Rejection Levels

Using a water whose coliform density is described by a gamma distribution with the parameters found above, assuming 100 per cent recovery efficiency with the MF method and a sampling error associated with MF counts which follows a Poisson distribution, the probability of finding exactly r colonies on a filter is:

$$P(r) = \frac{a^{p+1}}{p!}\int_0^\infty e^{-a\lambda}\lambda^p \frac{e^{-\lambda}\lambda^r}{r!}\,d\lambda$$

or:

$$P(r) = \frac{a^{p+1}(r+p)!}{p!r!(a+1)^{p+r+1}} \quad \ldots (8)$$

which is a negative binomial distribution. Changing notation to accord with that commonly used with the negative binomial, let $\frac{k}{m} = a$ and $k = p + 1$. Then:

$$P(r) = \left(1 + \frac{m}{k}\right)^{-k} \times \frac{\Gamma(k+r)}{\Gamma(r+1)\Gamma(k)}\left(\frac{m}{m+k}\right)^r \quad (9)$$

where

$$E(r) = m = 1.21 \text{ per ml.}$$

$$\text{Var } (r) = m + \frac{m^2}{k} = 4.88,$$

and the Lexis ratio $L = \sqrt{1 + \frac{m}{k}} = 2.0$ for a 100-ml sample volume.

To determine the rejection levels given in Table 1, the probabilities of the results 0, 1, 2, $\cdots$ n are summed until the 95 per cent level is reached, using a value of $m = 1.00$ for a 100-ml sample and corresponding values of m for other sample sizes. This is consistent with the average value of 1.0 per 100 ml in Sec. 1a of Table 1. For all sample sizes the Lexis ratio has been held constant at 2.0, a reasonable value for routine water examinations.

Quality Control Characteristic Charts

Curve A in Fig. 2 and 3 was constructed by evaluating β for various values of λ, by the following formula:

$$\sum_{x=3}^{5}\binom{5}{x}(1 - e^{-\lambda})^x e^{-(5-x)\lambda} = 1 - \beta$$

where β is the probability of *not* rejecting a sample when the true coliform density is λ per 10 ml.

Curve B in these figures was constructed by computing β for various values of λ from the formula $(1 - e^{-\lambda})^5 = 1 - \beta$.

In Fig. 2 and 3, the ordinate is $100(1 - \beta)$ and the abscissa is λ per 100 ml.

Curves C and D of Fig. 2 were constructed by evaluating, for various values of λ per 100 ml, and β from the equation

$$\sum_{i=0}^{7}\frac{e^{-2h\lambda}(2h\lambda)^i}{i!} = \beta$$

with $h = 1$ for Curve C and $h = \frac{1}{2}$ for Curve D. The curves are plotted with $100(1 - \beta)$ as ordinate and λ per 100 ml as the abscissa.

In a similar manner curves C and D of Fig. 3 were constructed by evaluating

$$\sum_{i=0}^{22}\frac{e^{-10h\lambda}(10h\lambda)^i}{i!} = \beta$$

and plotting $100(1 - \beta)$ against λ per 100 ml, with $h = 1$ for Curve C and $h = \frac{1}{2}$ for Curve D.

Considerations in Recreational Use of Impounding Reservoirs

Panel Discussion

A panel discussion presented on May 7, 1956, at the Diamond Jubilee Conference, St. Louis, Mo.

Robert B. Diemer

Gen. Mgr. & Chief. Engr., Metropolitan Water Dist. of Southern California, Los Angeles, Calif.

THE Metropolitan Water District of Southern California was organized in December 1928 to bring supplemental water from the Colorado River to the coastal plain of Southern California. At that time there were eleven cities, including Los Angeles, in the district which had a population of 2,000,000. Today there are 67 cities plus many large suburban areas, and the population of more than 6,000,000 is increasing at a rate of 300,000 persons annually. To provide recreational facilities for all the people now residing in the area and the many more expected in the near future, local sportsmen, playground directors, and others connected with recreation are exerting every effort to utilize all natural and artificial resources.

In 1931 the people of the area, by a vote of 5:1, approved a bond issue of $220,000,000 to build an aqueduct from the Colorado River to the Metropolitan Water District. This was designed to deliver 1,200,000 acre-ft of water annually to the semiarid cities where the rainfall averages about 15 in. annually and severe droughts of several years' duration are often experienced. During the period 1932–41, an aqueduct was built from the Colorado River across the state of California—a distance of 242 miles—to the terminal reservoir, Lake Mathews. This has a capacity of 107,000 acre-ft and a surface area of 2,000 acres, and is located 10 miles south of the city of Riverside and 50 miles east of Los Angeles. The aqueduct distribution system, including 150 miles of large-diameter pipelines, was put in operation in 1941 to deliver supplemental water in wholesale quantities to district member areas. The cost of the system, together with the expansion of its facilities, now well under way, exceeds $270,000,000. Plans are in progress to provide additional facilities within the next 5 years at an estimated cost of $100,000,000. Funds for the operation and maintenance of the aqueduct system, and for the payment of interest and redemption of the bonds, are raised by taxation and from water sales.

The waters of the Colorado River, the source of supply for the aqueduct and for Lake Mathews, rise principally in the high, snow-covered mountains of Colorado, Wyoming, New Mexico, and Utah, and flow through a practically uninhabited watershed from the Rocky Mountains through the Painted Desert and Grand Canyon region into Lake Mead. The water is thus almost free of bacterial and organic pollution. From Lake Mead it passes through

the power plant at Hoover Dam on its way to the aqueduct intake 150 miles below. Lake Mead and the river extending from Hoover Dam to the Mexican border provide excellent facilities for recreational use such as boating, swimming, fishing, and hunting, and a large degree of dilution for any pollution that may occur.

No recreational uses are permitted in any of the district's facilities, and every effort is made to prevent pollution. All reservoirs, both on the aqueduct and distribution systems, and the lined canal sections of the aqueduct, are fenced and are patrolled daily. Lake Mathews, the large terminal reservoir with a high-water surface area of 2,200 acres, is fenced and closed to all public activities. The total fenced area of 5,800 acres is not leased for farming, grazing, or any other purposes. To assist in prevention of pollution of the waters in the reservoir, the district acquired 8,800 acres in the watershed surrounding the reservoir.

During the construction of the aqueduct system the areas in San Bernardino and Riverside counties and that part of Los Angeles County lying east of La Verne, Calif., were not a part of the Metropolitan Water District. A softening and filtration plant with an initial capacity of 100 mgd and an ultimate capacity of 400 mgd was built at La Verne in 1941. The plant is located 36 miles below Lake Mathews on the upper feeder pipeline, which has a capacity of 750 cfs. A lower feeder pipeline—capacity 750 cfs—is now under construction. When domestic needs rise, filtration and softening facilities will be provided at a site on this feeder about 25 miles below Lake Mathews. A large suburban population will then, as now, be served directly from Lake Mathews without the protection of filtration.

Recreation Bill

During the 1955 regular session of the California legislature, a bill was introduced in the senate and assembly to permit recreational uses (especially fishing) in public and private reservoirs. The bill was amended to exclude chartered cities because of a ruling by the legislative counsel that it was unconstitutional as far as they were concerned. The bill was passed and sent to the governor for approval even though the State Board of Health expressed its opposition in the following resolution:

> The board recognizes that in certain situations recreational use of public water supplies under proper restrictions is feasible. The board, however, believes that present provisions of the Health and Safety Code afford needed protection to public water supplies while allowing restricted recreational use of water supply reservoirs when desired by local water purveyors and where it can be safely done.
>
> Therefore, the board desires to go on record as opposed to any enactment by the California State Legislature that would change the law so as to require public water supply reservoirs, whether publicly or privately owned, to be open to fishing or other recreational uses. Such requirement is, in its opinion, contrary to the best interests of the citizens of the State of California, in that it would constitute a potential danger to the public health, degrade the quality of water served to the public, and increase the cost of water to the consumer.

The California Section of AWWA went on record to oppose the bill authorizing multiple use of public water supply reservoirs as contrary to the best interests of the citizens who depend upon public water supplies administered by local governmental agencies, and requested the governor to veto the bill. The AWWA Board of Directors,

on Jun. 17, 1955, passed a resolution opposing the opening of domestic reservoirs for boating, fishing and recreational purposes and wired the governor of California to that effect. The governor refused to sign the bill and expressed appreciation at having received the benefit of the Association's views.

Lake Mathews

Proponents in favor of opening Lake Mathews for recreational activities claim that, by proper policing, the quality of the water can be kept suitable for domestic use. They point to San Diego (a member of the Metropolitan Water District since 1946) which has permitted fishing in its seven reservoirs for many years. The watersheds above its reservoirs are mostly uninhabited but are given considerable use for recreation, grazing, and highway travel. All water delivered through the city's system to the consumers, however, first passes through a filtration plant. Recently, the State Board of Health notified a Southern California community taking water from a reservoir where fishing is permitted, that simple chlorination will no longer be accepted, and that the water company serving the area must build a complete treatment plant or discontinue the use of water from that source.

Los Angeles

The Los Angeles Aqueduct was completed by the city in 1913 to bring water from the High Sierra, a distance of 250 miles. The Los Angeles Department of Water and Power, which provides domestic water to more than 2,200,000 people, has consistently opposed any public use or access to its reservoirs where such practice would constitute a threat to the safety of the drinking water. All department reservoirs above Haiwee Reservoir, the intake to the aqueduct, are open to recreational use for fishing, hunting, and boating. Below this reservoir the department has fifteen others with a total capacity of about 100,000 acre-ft, covering a surface area of 2,500 acres. None of these reservoirs is open for recreational purposes. As the Haiwee Reservoir (capacity 58,000 acre-ft) retains the water 30–90 days in storage before entry into the aqueduct, it, too, is not open to the public. The water leaving Haiwee Reservoir and flowing to the city through the Owens River Aqueduct has a high degree of natural purity. For this reason it has not been necessary to install filtration and treatment plants. Such installations would become necessary, however, if fishing or other recreational uses were permitted in the reservoirs presently closed to the public.

Class Legislation

Opening of reservoirs in Southern California for recreational purposes would be class legislation, as only a small percentage of the population could use them. Regardless of sanitary measures taken, there would be additional expense for safeguarding the water supply. For instance, if Lake Mathews were opened to fishing, plants to filter 1,500 cfs of water would have to be provided. Sportsmen claim that more than 1,000,000 fishing licenses are sold each year in all California and feel that these licensees should have a right to fish in public reservoirs built with public funds. A reservoir such as Lake Mathews, within an hour's drive of Los Angeles and easily accessible from several highways, would be a very popular place for fishermen among the 6,000,000 people in Southern California. California has plenty

of places for fishing: the Pacific Ocean, within an hour's drive of most Southern California cities, the Colorado River and Lake Mead above Hoover Dam, 300 miles away, and in the Sierra Nevada streams, which afford excellent fishing within 250 miles of Los Angeles.

All water agencies receiving water from the Colorado River Aqueduct and the Los Angeles Aqueduct should oppose every effort made to open their reservoirs. If recreational uses are to be provided on any reservoir by the enactment of new laws, it should be the obligation of the State Fish and Game Commission or some other recreational agency to provide the capital necessary to build treatment plants, pay for their operation, and be responsible to the State Board of Health for the character and quality of the water delivered from such opened reservoirs. This, however, is presently the proper responsibility of the Metropolitan Water District of Southern California.

Further Arguments

Another argument against opening of reservoirs to fishing is the occasional necessity for treating the water with copper sulfate to control the growth of aquatic weeds and algae. Water system operators would be criticized by fishermen if the regular chemical treatment of the water for this purpose resulted in the death of any fish. Thus there would be a conflict between the need to protect the fish and the far greater need to protect public health and preserve water quality.

Still another argument is related to security. Frequent inspections of district facilities are made by military officials for security purposes. In these days of continued international unrest this is very important. Opening the reservoir would permit any foreign agent to obtain detailed knowledge for potential enemies. The harm to the national defense effort would be untold if, for example, Lake Mathews were put out of commission.

The district plans to oppose all efforts to open this reservoir for fishing or any other recreational use because, in its present state, it can be much more adequately policed and protected against pollution by the public.

To reiterate, in the author's opinion, recreational use of water works impounding reservoirs in Southern California not already opened for these purposes should not be permitted.

Merrill L. Riehl

Supt. Water Purif., Mahoning Valley Sanitary Dist., Youngstown, Ohio.

Proponents of recreational use of water supply reservoirs seem not only to be in the majority, but seem to be more skillful in argument, with the result that they have misled many people. On the other hand, most water treatment personnel have been reluctant to come forward with their beliefs, although all those whom the author has questioned are in general agreement on this matter. The author's conclusions are based on experience with publicly owned systems having impounding reservoirs with and without recreational use.

It is possible that administrators of privately owned water supplies look at this problem from a slightly different viewpoint, inasmuch as they are in a position to make charges for recreational use that are more than sufficient to cover the expenses involved in enforcing the regulations necessary to

minimize pollution. Publicly owned water supplies, however, cannot carry such expenses, because the viewpoint that the public should have free use of public property prevents the program from paying its way.

There is no question that it is difficult to overcome the public apathy to the need for an adequate, safe, and palatable water supply. In order to persuade the voters to approve the expenditures for such needs, the water department all too often must secure assistance from every source. This includes recreation-minded groups whose help is often asked and whose cooperation, of course, leaves the water department under obligation. The water department, in other words, may be forced to take half a loaf or none at all.

Need for Safeguards

Although these are the existing facts, water works men have no reason to cease vigilance. If more of them express their views, it may help others in their battle to have the best supply possible. Water works men owe the public one thing: an adequate, safe, and palatable supply. This obligation must be fulfilled without compromise, and one of the best means of doing this is by safeguarding the raw supply. This situation may be compared to the present views on milk sanitation. After pasteurization was proved effective, there was a tendency to pay very little attention to the sanitary conditions under which the raw milk was produced. Almost any milk could be made to be "safe." Today, however, the picture is changed. Every one is aware of the carefully controlled conditions of sanitary practice that are imperative at the dairy barns. Pasteurization has become only an additional factor of safety. Water supply interests are presently passing the stage where there is a desire to rely entirely on treatment, particularly chlorination, to protect the water supply. Rather, it is imperative now to have raw water that is as good as it possibly can be, so that chlorination and other treatment become additional factors of safety instead of the entire solution. There is still a long way to go to reach this ideal state, but opening reservoirs to recreational use certainly is a step backward, not forward.

Additional Problems

Before any water department official compromises himself by settling for half a loaf, he should consider the following additional problems which will accompany recreational use:

1. The pollution load will be greater. It has been stated that practically all public water courses are now polluted and that recreational use would add very little to the load. Even the slightest pollution should not be ignored, however, and every attempt should be made to reduce instead of increase the load. Furthermore, if the waters are heavily polluted, there is reason to question their suitability for recreational use, and if they are not heavily loaded, the additional load may result in a dangerous condition.

2. The water is more difficult to treat, increasing the cost for chemicals to assure proper taste and odor control. Additional screening procedures are also required.

3. The public should have, and is entitled to, a reservoir that is not littered and repulsive to the eye but recreational use makes this almost impracticable, even with constant policing.

4. The additional costs of policing the grounds, maintaining facilities such as picnic tables, shelters, wells, rest rooms, and boat ramps are appreciable. If the utility assumes this cost, the consumer has to pay for it. If part of the cost is assumed by recreational groups, the utility then compromises on control of the reservoir.

5. Public use creates fire hazards to the shore plantings which are so important in minimizing silting of the reservoir. The fire hazard is even greater where evergreens are planted completely around the shore line for screening out deciduous leaves, which are troublesome in taste, odor, and color control. Evergreen planting with its resultant pine needle cushion is desirable for several other reasons: it gives better sheet erosion control, retards runoff of snow and ice, helps sustain stream flow, rehabilitates springs, and reduces loss by transpiration. (Another reason why public use is not compatible with heavy evergreen planting is its interference with such activities as fishing from the bank.)

6. The operating utility is subject to large claims for accidents occurring on the grounds, and must either carry broad insurance or risk costly lawsuits.

7. Demands which are contrary to the best interests of the water supply user will be made by groups wishing to increase recreational value. Requests may be made for limited planting of shore line, restrictions on use of algicides in the reservoir, and maintenance of constant level.

8. Because of the greater number of potential offenders on the grounds, limited recreational use is more difficult to enforce than none at all. (Unlimited recreational use, with no regulatory control, would be unthinkable because of the pollution hazard.)

9. Recreational privileges bring a demand for cottage sites. This should not be tolerated because of the much greater pollution load entailed. If this privilege is not granted, however, there will be constant pressure from persons with political prestige. Additional pressure will be brought to bear for trailer parking and tenting privileges on the grounds.

10. The possibility of pollution or contamination by sabotage is greatly increased by public access to the water supply.

Conclusion

Water works men must never forget their obligation to *all* the consumers, although they get little or no expression of appreciation for their vigilance. Other agencies must not be allowed to interfere with this obligation, although they may be very convincing in their arguments and may have almost unlimited capacity to gain so-called public support for their demands. Water works men must be able to evaluate these arguments. It is easy to see how pressure from those who speak loudly may wear water works men down to the point where they take the path of least resistance and overlook the welfare of the consumers. It must be remembered that opening the reservoirs to the public can make it a little bit easier for that "impossible" epidemic to strike, and, if it does, it is the water works man, not the recreational users, who will be held responsible by the consumers and public health officials.

Alexander J. Minkus

Purif. Engr., Water Bureau of the Metropolitan Dist., Hartford, Conn.

In New England, because of the hilly terrain, it has been relatively easy

in the past to obtain water supplies from upland sources. These are generally lakes and ponds of glacial origin or impounded upland streams. About 60 per cent of public supplies in New England derive from these sources. Fortunately, the large centers of population are located along the rivers and in lowlands so that their drainage wastes generally do not endanger public supply. This situation has allowed 75 per cent of New England municipalities using impounded supplies to establish only two quality safeguards: sanitary control of the watershed and chlorination. The remaining 25 per cent must filter their reservoir supplies.

Crowding of Areas

The policy of removing the bars provided by sanitary control of watersheds is one of major retrenchment. The population density along the Atlantic seaboard is a high one with Rhode Island, New Jersey, Massachusetts, Connecticut, and New York having an average density of 309–748 persons per square mile. The national average is 51 persons per square mile. These figures indicate that there might be danger in allowing the recreational use of watersheds protected only by chlorination.

Experience shows that people will crowd to watersheds once restrictions have been removed. Fishing and bathing are allowed in the Hartford metropolitan district reservoir which has a surface area of about 400 acres. This impounded water, known as the Compensating Reservoir, is never used as a drinking-water supply and is therefore open to the public for recreational purposes. It is not uncommon for 10,000 people to visit on a summer weekend. Parking problems prohibit more from coming. This is not surprising for over a million people live within a radius of 30 miles, or one hour's easy drive. The drinking-water supply reservoirs are in the same area and, if used for recreational purposes, they would undoubtedly attract a comparable number of people and be subject to the same hazard.

As a result of the building boom in the past decade, more and more homes have been built on the outskirts of towns, and these have come closer and closer to the reservoir watersheds. Hartford's original upland water supply, situated in West Hartford, and now kept as an emergency reserve, is on the fringe of a community of 60,000 people, all located within 4 miles of the reservoirs, or a little more than an hour's walking time. With such ready access, many people who have never fished might take up the sport if given a chance. The situation is similar in other cities.

Connectitcut issues 112,000 fishing licenses annually. Fishing trips often are family excursions, bringing the possible number of watershed users to 300,000–400,000. Still others would be interested in bathing and picnicking. The inevitable increase in pollution load would be more than a single-stage treatment process could handle.

Pollution

Experience shows that the degree of pollution is directly related to the number of persons allowed on a watershed. Hartford's Compensating Reservoir is by necessity drawn down rapidly, exposing an astonishing amount of debris along the shore line. A very short distance from the water's edge there is ample evidence that the toilet facilities which have been provided are not always used. A crew of four or five men and a truck working five days a week keep the shore line clean.

The experience of Concord, N.H., in 1951 was that this kind of contamination can be too great for simple marginal chlorination to overcome, and that once in the system, it is hard to eliminate (*1*). At Concord, fecal deposits on the watershed at Penacock Lake raised the coliform-organism content in the distribution system to 240 per 100 ml, though the water had been dosed with 0.25–0.30 ppm chlorine. Two weeks of constant flushing and chlorination in excess of 50 ppm were needed to purge the distribution system of high coliform-organism contents.

Cost Factors

To provide control of watersheds, many water departments have acquired extensive areas of land. For this purpose the Hartford metropolitan district owns 32 square miles of land. Allowing the public free access to this land would nullify the reasons for possessing this vast amount of real estate. The land holdings are in many instances located in another township and are therefore sometimes taxed heavily. This creates a situation where the people of one town pay for the recreation of others.

The sanitary code of the Connecticut State Health Department, as well as that of other states, has rigid regulations covering the location of pigpens, privies, and septic tanks on reservoir watershed properties, however remote the properties may be from the reservoirs. Municipal water departments have spent substantial sums to have the management of these facilities brought into conformity with sanitary codes. Again, all this is for naught if the impounded waters are subjected to the pollution from large numbers of people.

Some privately owned water companies in New England feel that orders to open their property to trespass are illegal, and they are ready to contest the question all the way to the Supreme Court. The public water departments are apprehensive of the liability claims that are bound to be made on the grounds they had maintained invitational hazards.

Dangers

Opening the reservoirs for recreational purposes increases the dangers of forest fires. There is very little virgin timber in Connecticut, most of it being of secondary growth, usually nurtured by a water department. It would be a shame to increase the risks of losing this natural resource.

Lastly, the strategic value of watershed areas can be cited. Small as it is, Connecticut has four critical target areas. Representatives of the US Army visit these water systems periodically to check on security methods. Civil defense measures would be harmed if prospective saboteurs, disguised as fishermen, were openly invited to take note of structure and operating procedure details.

The larger rivers in Connecticut and the other eastern states carry a pollution load inimical to fishing and bathing but there are nevertheless great recreational potentials in these rivers. Sportsmen would benefit the community as a whole much more if they were to direct their energy to clearing up these rivers, rather than attempt to extend a practice which holds so much danger to so many people.

Reference

1. Faneuf, A. G. & Healy, W. A. Misuse of Watershed Caused Poilution at Concord, N.H. *W. W. Eng.*, **105**:131 (Feb. 1952).

Discussion

The two statements which follow were not part of the regular conference program. The remarks of Harold J. Toole were read as part of the floor discussion following the formal presentation. And E. Sherman Chase's comments upon these remarks were prepared after the meeting to put into the record the objections that many engineers have to present watershed policy of the Massachusetts District Commission. Mr. Toole has asked us to note that Quabbin Reservoir was opened to boat fishing by an executive order contrary to his recommendation.

Harold J. Toole

Director, Water Div., Metropolitan District Com., Boston, Mass.

The Wachusett Reservoir, which contains approximately 65 bil gal of water, has been open to shore fishing for over 30 years. Permits are restricted to residents of the four towns surrounding the reservoir and to residents of the Metropolitan Water District. Special permits are issued at a cost of 25 cents. During the past few years, approximately 2,500 permits have been issued for this reservoir annually.

Quabbin Reservoir was originally opened to shore fishing in restricted areas by legislative act in 1946, and in 1952 the reservoir was opened to boat fishing in limited areas. The commission established three boat-mooring areas and purchased 100 14-ft outboard motor skiffs, 50 5-hp outboard motors, and other miscellaneous equipment.

Rules and regulations governing use of the Quabbin area for fishing are shown in the Appendix. Following is a 1953 schedule of rates charged for the rental of equipment and the use of facilities:

Outboard-motor skiffs rent for $3 per day or 50 cents per hour or any fraction thereof. Outboard motors are available at $4 per day or 75 cents per hour or any fraction thereof.

Persons renting the commission's boats or motors are not obliged to pay the 50-cent fee required under Rule 7 of the rules and regulations.

The commission furnishes a full tank of gasoline plus an additional 2½-gal safety can of gas. Any additional gasoline must be paid for at the rate of 35 cents per gallon.

A parking fee of 50 cents per day per car is charged for the use of the parking area and other facilities when they are used in connection with shore fishing only.

In 1953, approximately 18,000 persons used the facilities. This number was increased to approximately 35,000 in 1954. In 1955 the number was somewhat reduced to approximately 28,000 because of the hurricanes and floods in August and October. Boat-mooring area No. 1 was closed in August for the remainder of the season because the access road was washed away during the flood.

The Department of Natural Resources, Division of Fisheries and Game, has cooperated with the commission in carrying on an extensive stocking program. In 1954 the reservoir was stocked with the following fish: 150,000 walleyed pike (fry), 2,500 walleyed pike (fingerlings), 1,800 walleyed pike (adults), and 69,300 lake trout (fingerlings). In 1955 it was stocked with the following: 111,255 lake, brook, and rainbow trout (1½, 2, 3, and 10 in.), 4,765,042 walleyed pike (fry and 7–11 in.).

The entire program has been enthusiastically received by the sportsmen of Massachusetts and of the adjoining states, and they have cooperated wholeheartedly by complying with sanitary rules and regulations. When the fishing program was initiated, the number of water sampling stations on the reservoir was increased, and to date, analyses of samples do not indicate any pollution arising from the use of the reservoir for boat fishing. It should be pointed out that consent to the use of the reservoir as a general, recreational boating area would never be granted, and that one point in favor of allowing boat fishing at Quabbin is the tremendous size of the reservoir and the large volume of water stored in it—415 billion gallons.

E. Sherman Chase

Partner, Metcalf & Eddy, Engrs., Statler Bldg., Boston, Mass.

The statement on Massachusetts policy in the matter of recreational use of the Wachusett and Quabbin reservoirs, described by Harry J. Toole, is particularly disturbing in that the use of the reservoir waters is encouraged and abetted by periodic stocking and by provision of facilities for fishing.

It is true that both reservoirs, under ordinary conditions, provide many days' storage and correspondingly great opportunity for the normal decline of disease organisms which might reach the impounded waters. Although the chance that fishermen at either reservoir will contribute such organisms to the water may be remote, fishermen as a class are no more likely to refrain from responding to calls of nature than are the rest of us, just because they are on the shores of a water supply reservoir. Rules and regulations are useful to a certain extent, but several years experience in New York state show that, by and large, the benefit of regulatory dicta is distinctly illusory.

Massachusetts, as is true of most areas in New England, has many water courses and ponds which are not used for water supply purposes and which are readily accessible for recreational use as well as for fishing. Furthermore, the many miles of ocean shore and the ocean itself constitute ample opportunity for water recreation. There is a trait in human nature, possibly inherited from Adam and Eve, which impels the best of us to rebel at any prohibition whatsoever. For years fishermen have rebelled against rules preventing fishing in water supply ponds and reservoirs, and, irrespective of the many other opportunities for fishing in unrestricted waters, have sought the use of sources reserved for water supply.

The Quabbin Reservoir is a beautiful body of water. The shores would provide ideal sites for summer camps and cottages. To admit one group of citizens to the use of the shores and waters is discrimination with respect to others who might like to camp around the reservoir and boat upon its waters. Such an argument might be advanced by Boy Scout and Girl Scout groups. It has already been proposed that a state prison colony be located on the Quabbin drainage area.

Perhaps the most disturbing aspect of the Massachusetts policy in this matter is that it provides the advocates of the recreational use of other and smaller reservoirs with an argument somewhat difficult to combat. There are too many sanitary hazards which are difficult to guard against, without adding those which, although they may be remote, can be prevented.

APPENDIX

Metropolitan District Commission Rules and Regulations Relative to the Use of Lands and Waters at Quabbin Reservoir for Fishing Purposes

1. All acts that pollute the water supply or injure the property of the commonwealth are prohibited. No human excrement shall be deposited or discharged upon or into the ground at any place from which such excrement may flow or be washed or carried into the Quabbin Reservoir, or any stream, ditch or water course tributary thereto. Persons fishing from boats must use the sanitary facilities provided at mooring areas.

2. No person shall tamper with or damage any gate, barrier or lock, or deface or defile any signs, trees or other property of the commonwealth.

3. No person shall bathe or wade in Quabbin Reservoir and no person shall skate on or fish through the ice or from the shores of any part of said reservoir or of the streams tributary thereto, except as permitted by Chapter 421 of the Acts of 1946, as amended by Chapter 300 of the Acts of 1947.

4. Building fires, picnicking, smoking on the lands of the commission, hunting, shooting and trapping are prohibited. Fishermen will be allowed to carry lunches and smoke while in boats on the reservoir. No person shall carry on his person or transport in any vehicle firearms of any nature on the lands or waters of the commission.

5. No person shall drink or have in his possession alcoholic beverages while on the lands or waters of the commission.

6. All tin cans, bottles, excess bait, rubbish and refuse of any nature, incidental to the enjoyment of the privilege of fishing in Quabbin Reservoir, shall be deposited in rubbish cans or other receptacles which may be provided for this purpose, or said materials shall be removed from the lands of the commission. No refuse of any nature shall be thrown into the reservoir. No fish shall be cleaned on the property of the commission.

7. Persons sixteen years of age or over who possess state fishing or sporting licenses will be allowed to fish from boats in designated areas, under special permits issued by the commission. A fee of 50 cents per day will be charged each person permitted to fish from boats on Quabbin Reservoir who uses his own equipment.

8. Persons permitted to fish from boats shall, at all times, be responsible for the sanitary condition of the boat. Persons under sixteen years of age may not boat upon the designated portions of the reservoir unless accompanied by a licensed adult.

9. Only substantial rowboats of a minimum length of 12 ft and of a type considered safe by the commission representative in charge shall be used. No sailboats or inboard-motor boats, canoes, collapsible boats or other similar craft will be permitted in the waters designated. Outboard motors shall have a rating of not more than 10 hp. Boats less than 14 ft 6 in. in length will be limited to three occupants, and boats of that length and in excess thereof may be licensed to carry four occupants. No boat shall carry in excess of four occupants. All boats must carry an approved life preserver for each occupant. All boats using outboard motors must be equipped with an approved fire extinguisher and a set of oars and oar locks in first-class condition.

10. No person shall operate a motor propelled boat at a speed other than reasonable and proper, or in such a manner as to annoy or endanger the occupants of other boats.

11. Boats shall not be placed in the water, except at designated mooring areas and not until the fishing season is officially opened or when the ice leaves the reservoir—whichever is the later. All

privately owned boats, motors and other equipment must be removed from the property of the commission each day until further notice.

12. Boats shall not leave the mooring areas before 6 AM and must return at a time posted at each mooring area. The beaching of boats at any point, except at the designated mooring areas, is strictly prohibited, except in cases of extreme emergency.

13. No boating will be allowed on the reservoir, outside of the limits of designated fishing areas, as shown on a plan of the Metropolitan District Commission dated Apr. 24, 1952.

14. No person shall refuse or neglect to obey any reasonable request made or order given by officers or employees of the Metropolitan District Commission or the Department of Conservation whose duty it is to enforce these rules and regulations or the state fish and game laws.

15. Specific information regarding the fishing areas may be obtained by applying in person or by mail to the Supt., Quabbin Section of the Water Division of the Metropolitan District Commission at the Administration Building, Belchertown, or at the office of the Water Division at 20 Somerset Street, Boston, Mass., between the hours of 9 AM and 5 PM, Monday through Friday, excepting holidays.

16. Any violation of these rules and regulations by a permittee or by a minor accompanying the permittee will be deemed sufficient cause for the immediate revocation of the permit.

Any person violating any of the above rules and regulations shall be punished by a fine of not more than 500 dollars or by imprisonment not exceeding one year in the house of correction, or both, in accordance with the provisions of Chapter 300 of the Acts of 1947. The Metropolitan District Commission and its employees are not responsible for any damage to or loss of property sustained by a permittee, or for any injury or loss of life which may be incurred in connection with the exercise of boating permits issued by the commission.

The above rules and regulations relative to the use of lands and waters at Quabbin Reservoir for fishing purposes were adopted by the Metropolitan District Commission on Feb. 19, 1953.

The Engineer's Responsibility to His Client

—O. B. Curtis Sr.—

A paper presented Oct. 31, 1955, at the Alabama-Mississippi Section Meeting, Biloxi, Miss., by O. B. Curtis, Sr., Secy., and member, Mississippi State Board of Registration for Professional Engrs., Jackson, Miss.

AN engineer's responsibility to his client amounts to a summary of engineers' codes of ethics—less, perhaps, portions which deal with behavior *between* engineers, plus certain good business practices applicable to any business. There is nearly complete congruence between an engineer's responsibility to a client, and his responsibility to himself. This discussion will be in terms of an engineer with an average job in a modest organization rather than in terms of the larger organizations and their "super-jobs."

First Responsibility

It is appropriate to consider those responsibilities which are frequently abridged or left unfulfilled, or those which are of such importance that they can not be neglected. An engineer's first responsibility begins immediately. He should accept only that assignment on which he is quite certain he can deliver an economical, sound, modern, job. He should accept only that assignment for which he is qualified by experience or training to deliver a comprehensive analysis of all parts, including a reasonably accurate preliminary estimate of cost, where a report or study is involved.

An engineer may find it expedient to employ one or more consultants or specialists to perfect certain phases of the work. Such perfecting usually consists of the design or inclusion of up-to-date machines, processes or materials, the detailing of special or complicated parts, the writing of specifications to conform with unfamiliar codes, or the designing of an important unit by one who has specialized in that type of work—for example, the design of treatment plants or pumping stations in city sewage systems, the design of swimming pools or drives and parking areas which are part of a larger improvement.

An engineer should freely admit his limitations, even in his chosen field, and should not be embarrassed to discuss the matter of obtaining consultant help. The advancement has been so great in all phases of engineering that a man may well be proud if he has learned thoroughly the best and most acceptable methods in one area. Each person's own experiences if of great depth must necessarily be narrow, and if very broad must necessarily be without much depth. An engineer's qualifications are comparable to the foundation of a bridge. In selected areas, his experience runs deep, like the piling beneath the footings, but superimposed on these pilings are the footings which have complete coverage of a broader area with much less depth.

Tactfulness

A second major responsibility concerns tactfulness. If, for example, the client is politically prominent, the engineer and his employees must conduct themselves in such a manner that the client's prestige and public esteem do not suffer. This involves tactful dealings with the client's constituents as well as thorough and repeated instructions to all subordinates. Nearly all public improvement projects inflict damages on property or infringe the rights of one or more owners. It matters not whether these owners have been compensated—they usually remain aggrieved, and are ready to air their grievances to the engineer, his representatives, or even to the construction workers. The engineer's instructions to his representatives should include directions to the contractor's supervisory personnel regarding the conduct of his employees.

In the event the owner holds a nonpolitical position, equal and similar care should be exercised to see that he receives no damage either from the public or from his own clients or customers. This matter is so important to so many construction projects that it deserves continuous checking for results.

Legal Protection of Client

Another important responsibility of an engineer to his client lies in the area of public liability. He should exercise his professional judgment to prevent the client from making decisions which will incur liability. One broad example of such decisions would be reduction of the costs to conform with the funds available, where the modification or limitation would result in future injury or damage to property. An example of wise counsel by the engineer would be the recommendation that damaged property be protected by the contractor at the client's expense, in order to arrest or minimize the damage until restoration can be made.

Further responsibility lies in the legal field. Wording of the general requirements and covenants of specifications should be approved by competent legal talent. This includes the processes for awarding and executing contracts, those for fixing bonds, the scope of work, legal relations, contractor's responsibility to the public for conditions which control the prosecution and progress of the work, additions, deletions, and negotiations for extra work.

Limits of Authority

The field of allocation of responsibilities is also important. Frequently an inspector (whose principal qualifications include longevity) will consult with a contractor's superintendent whose qualifications also derive from experience on similar jobs, and they will agree to waive an apparently minor work procedure called for by the specifications. They will reason that it costs more than it is worth, and that they have successfully completed many good jobs without using this procedure. The item eliminated may be a work procedure approved and adopted by an organization which is national in scope, such as the AWWA or the American Road Builders Association, and, hence, a procedure which has been found, after multiple trials, to be well worth the added cost. Broad examples would be changes in methods of calking pipe joints and in the preparation of trench beds. Others involve additional base watering, denser base compaction, longer rolling, and so on.

One case where a resident inspector reduced the thickness of a gravel base from 14 in. to 6 in. in contravention of the specifications, was detected through pavement failure, and the cost of restoration exceeded the entire engineering cost. An engineer should define both to his men and to the contractor the limits of authority of his subordinates, and these definitions of authority should be recorded.

More applicable to the larger firms and to larger jobs is the question of top-level conferences. In general, the client hesitates to call the engineer back to a succeeding conference shortly after the conclusion of a previous one, and, too often, the top-level engineers of a large firm do not make themselves easily available for needed conferences, even though they retain responsibility for final decisions.

Although a separate fee is appropriate for cases of litigation, too many engineers do not make themselves available or fail to provide the many facts usually required in a lawsuit.

Another responsibility lies in the field of job records. An accurate record of the progress of a job is a "must." This includes date of starting, dates of moving and removing units of equipment, contractor's forces employed each day, type of work in progress, its location, and the nature of engineering services, plus notes on weather conditions, official visitors, delays, potential delays, and similar matters. In disputes, lawsuits, and other difficulties, the job record assumes an importance far above its usual one.

An engineer should devote his time and energy, and that of his subordinates, to seeing that the client receives full value for his money, consistent with the limitations of the contract. This responsibility includes the furnishing of sufficient competent subordinates to assure compliance with the specifications.

Honesty

It is the engineer's responsibility, too, to see that neither he nor any employee is interested financially in any company, corporation, or enterprise within his jurisdiction on the project involved, and that none of his employees receives gratuities, employment, or compensation of any description in exchange for directed purchases, biased decisions, or alteration of the plans or specifications. It is appropriate for a contractor or a manufacturer to reward an engineer or his subordinates for developing a new use for a product, a new procedure for a machine, or even new techniques in methods. Such rewards, however, should be made with the full knowledge and consent of the client.

Economic Importance of Contracts in Water Works Construction

Robert M. Dixon

A paper presented on Oct. 18, 1955, at the Southwest Section Meeting, San Antonio, Tex., by Robert M. Dixon, Chairman, State Board of Water Engrs., Austin, Tex.

FEW concerns of water works officials exceed in importance that of keeping costs as low as possible. Water supply development is primarily an engineering function and should be handled only by engineers who have broad experience, professional proficiency and sound judgment. Good engineering can often mean a difference of 10–25 per cent or more in construction costs. Money is short in all budgets today, and one is compelled to promote economies wherever possible. Attention to some of the following can help accomplish this goal.

Equitable Contracts

1. Provide contract documents which are equitable to both the owner and the contractor. It is quite common that overprotection of the owner in the contract form can cost money which need not be spent. The contractor must protect himself against unforeseen conditions. He must gamble against these conditions, and it is the community that should carry the major portion of this risk.

2. Avoid, as far as possible, the use of phrases in the contract document such as "to the satisfaction of the engineer," "by order of the engineer," or "by direction of the engineer." Persuade the engineer to give the contractor the choice of methods of construction, provided results meet the needs of the job, produce the production that is desired, and function in accordance with the designing purpose. Contractors must be alert to select the latest methods of construction, because they are in a competitive market, and new methods of handling materials are their stock in trade. In order to avoid these faults and make a profit on the job, some contract documents specify the procedures that are to be used. This puts a damper on the contractor's ingenuity, and may be a deterrent to progress which, in turn, will raise costs.

3. Avoid writing specifications that require special equipment and materials which are not of standard manufacture, unless nothing but the special equipment or materials will produce the results desired. Tricky designs and nonstandard materials and equipment which are not supported by an adequate experience record are risky to the owner and to the contractor as well. Closed specifications should be discouraged, and careful attention should be given to accepting process layouts which cannot be checked by the engineer against his own past experience. Contractors are not in a position to know what processes are

or are not patented, and they are rarely in a position to determine this in the short time made available for bidding. The owner should retain the responsibility for determining patented processes and the consequent fees to be paid.

4. Encourage close cooperation between engineers and contractors during the design period, because contractors can often supply ideas that will permit more economical construction, together with a high-quality job.

5. Use competitive bidding and avoid the waste and inefficiency that can result from day labor methods. Where jobs are publicly advertised for a sufficient length of time, the public benefits through having given the various contractors an opportunity to bid the job and to base their bids upon the most modern methods and procedures, making use of the latest equipment available to the bidders and utilizing crews which are skilled in this type of work. Where recognized accounting methods are used on construction jobs done by day labor, it has been almost uniformly proven that work done by the contract method is cheaper than work done by the owner with his own forces. There are several reasons for this:

a. The contractor has to come within his bid price to break even or to make a profit.

b. The incentive to do this is evident and is lacking when the cost is not determined before the start of the work.

c. The owner is protected against additional cost when the job is bid and awarded on a competitive bidding basis because the contractor is bonded, and if he is unable to finish the job, the bonding company is obligated to do so. The community, water district, or other owners thus need not gamble on the final job cost.

6. Avoid the practice of buying materials and equipment direct rather than letting the contractor purchase them on the job. Much has been said about buying direct and saving the contractor's profit but this position should be analyzed very carefully to determine whether the job might not cost more if this procedure is followed. It takes highly skilled "know how," organizing ability, and a desire to push the job through to completion in a reasonable time to keep waste and inefficiency low. Many pitfalls await the inexperienced owner if he listens to the salesman's admonition: "Buy it direct and save the contractor's profit." Where materials and equipment are bought direct, it prevents the contractor from scheduling his construction as well as he could with direct control over the sources of the material and equipment. If he is denied this control, he may find it necessary to increase his overhead. Where it is necessary to order pumps and have them on the job within a given length of time, or where other special equipment that requires extra time to procure is involved, the "buy it direct" argument may have some substance, but these should be determined in each instance and held to the minimum if possible.

Another reason that makes it evident that communities cannot buy the material and equipment as cheaply as contractors is that direct purchasing must be done on public quotations, and, therefore, the price is set for competition on those particular items. If they are bought by the contractors, the prices are not made public and all competitive forces can be brought into play.

Many municipalities and their engineers argue that they cannot get the best material and equipment if a contractor buys it for the job. This statement, when analyzed, does not carry much force, because the engineer can establish that any materials and equipment furnished on the job shall be purchased only after his approval. Contractors will necessarily buy as cheaply as the engineer or general specifications permit. It is the responsibility of the engineers to see that the kind of material and equipment is clearly specified so that the contractor is not deluded into thinking he can buy cheaply, only to have the engineer deny him this privilege by requiring higher grade material or equipment than was specified.

7. Provide for arbitration in the construction contract and exclude statements that the engineer's decision is final. It has been the experience of the construction industry that this produces unfair settlements with no appeal to the courts, and consequent dissatisfaction.

8. Make complete studies of the construction requirements and provide enough money in the bond issue to cover them all. When adequate funds are not available to do the desired job, unpleasantness and inferior production often result. It is not the engineer's estimate, but the bidder's analysis of the job and the bid that he submits that control the final cost. Good engineers will not make estimates which are below current construction costs, nor will responsible contractors submit bids predicated upon an engineering estimate rather than their own take-off from the plans and from examination of the site.

9. The construction industry as a whole is interested in seeing that the taxpayer gets his money's worth, but there should be safeguards against the irresponsible bidder. Awarding authorities should be willing to refuse to award to the low bid unless the bidder is responsible. Awarding authorities should also carefully check the bonding company's solvency, and determine for themselves that they are fully protected by such bond. The US Treasury Department furnishes a list of accredited bonding and surety companies and gives the capacity for which each is recognized in terms of federal construction. This is usually a safe list to follow.

Conclusion

In the final analysis, the awarding body can expect to get no more for its money than it is due in an open and competitive market. It should not expect a bargain through competitive bidding and certainly cannot anticipate a bargain by doing the work itself. When construction is taken out of the hands of those who have the trained crews, the applicable equipment and the technical "know how," a poor job at a high price must be expected.

There is no sure way to save every possible dollar of construction costs, but if sound business methods are followed, if the engineering is done by capable, responsible and experienced engineers, and if bids are awarded to responsible contractors after an adequate time has been allowed for bidding, then the public can be assured that it is being provided as many safeguards as possible in the expenditure of its tax money.

Maintenance and Inspection Methods for Valves and Hydrants

R. L. Lawrence

A paper presented on Oct. 18, 1955, at the Southwest Section Meeting, San Antonio, Tex., by R. L. Lawrence, Supt., Water Dept., Alexandria, La.

REGARDLESS of the size of a water distribution system, and in spite of the complete absence of consumer concern as to the constant lack of personnel in most utilities, uninterrupted service is mandatory during these days of increased manufacturing, air conditioning, lawn-sprinkling systems, multiple-bath residences, and other uses. The consumer has little sympathy for the water works that, for some reason, fails to provide uninterrupted service, even when notification is possible. Continued routine inspection of a water works' facilities and preventive and corrective maintenance programs are, therefore, major responsibilities of water works administration. These are not jobs that can be put off until other jobs are completed or men are available; they must be done continuously, with routine inspection scheduled and carried out at its proper time, to the exclusion of all other work, with the exception of emergencies.

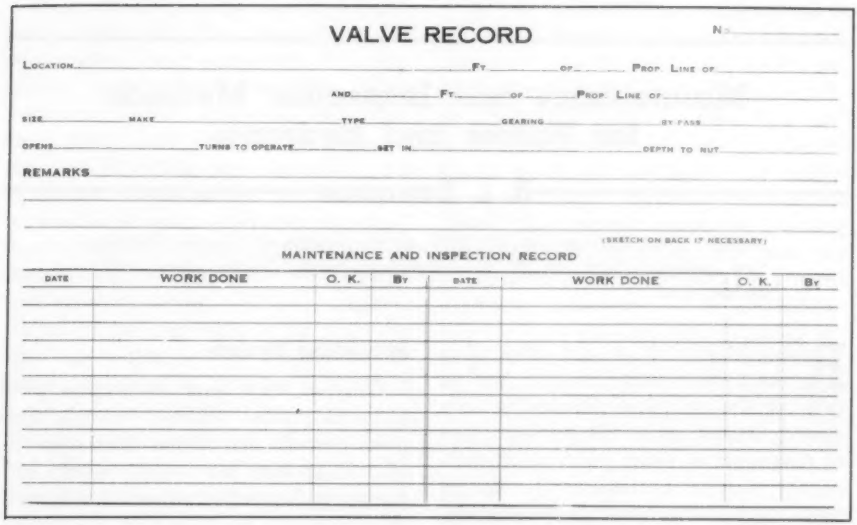
Because this article is concerned only with valves and hydrants, other facilities will be referred to only in passing. Within the distribution system, maintenance problems are, perhaps, most acute in valves and hydrants, but trouble can be anticipated if a good inspection program is adopted.

Recording System

Only a very poor inspection program can exist without records, and poor records are worse than none at all. Therefore, for a water works initiating an inspection program, it is well that records be prepared for every valve and hydrant in the system. Where locations and measurements are unknown, this initial preparation of records can be coordinated with the preliminary inspection program. Later, when records are definite, more comprehensive maintenance and inspection can be arranged.

There have been a number of recommended systems for the establishing of records. Alexandria, La., has adopted a modification of the record cards suggested in the Association's standard on this subject (*1*).

The valve and hydrant record cards, shown in Fig. 1 and 2, are 5 × 8 in. On each card are blanks for all pertinent information for any particular valve or hydrant. The first and most important entry is the location of the item; the rest of the card is self-explanatory. It is emphasized that the degree of success of future inspection trips depends upon the degree of accuracy with which foremen post the information required on the card. On



VALVE RECORD

No.

LOCATION Ft. of Prop. Line of

and Ft. of Prop. Line of

SIZE MAKE TYPE GEARING BY PASS

OPENS TURNS TO OPERATE SET IN DEPTH TO NUT

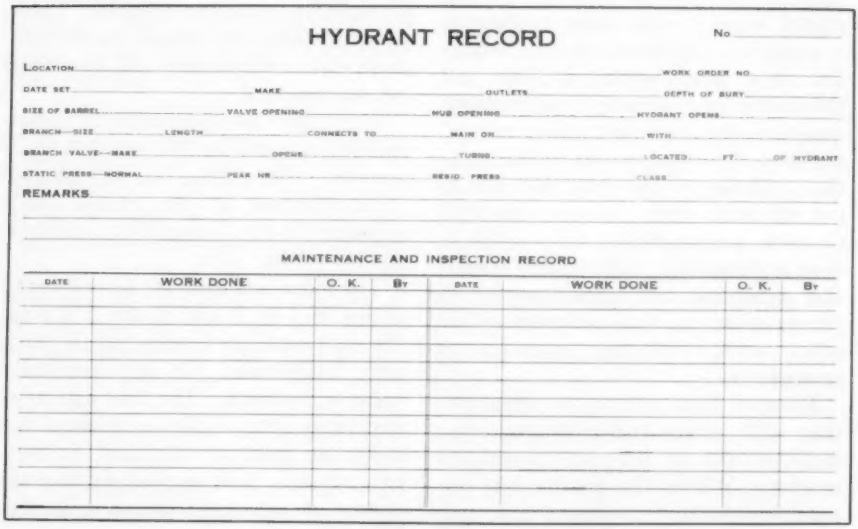
REMARKS

(SKETCH ON BACK IF NECESSARY)

MAINTENANCE AND INSPECTION RECORD

DATE	WORK DONE	O. K.	By	DATE	WORK DONE	O. K.	By

Fig. 1. Record Card for Valve Maintenance



HYDRANT RECORD

No.

LOCATION WORK ORDER NO.

DATE SET MAKE OUTLETS DEPTH OF BURY

SIZE OF BARREL VALVE OPENING HUB OPENING HYDRANT OPENS

BRANCH—SIZE LENGTH CONNECTS TO MAIN ON WITH

BRANCH VALVE—MAKE OPENS TURNS LOCATED FT. OF HYDRANT

STATIC PRESS—NORMAL PEAK HR RESID. PRESS CLASS

REMARKS

MAINTENANCE AND INSPECTION RECORD

DATE	WORK DONE	O. K.	By	DATE	WORK DONE	O. K.	By

Fig. 2. Record Card for Hydrant Maintenance

the reverse side of the cards, outlined squares represent city blocks and street intersections, for use if sketches need to be made.

When measurements are taken for filling in the record cards, they must be made from property lines or street center lines, rather than from power line poles or ditch banks. After cards are prepared for existing installations, it is a simple matter to file a card for each new installation by instructing the foreman of the job to prepare a field card which will later be presented at the office for typing and filing.

Valves can be numbered according to intersection numbers such as I-20-2, the "I" indicating intersection, "20," the intersection number, and "2" the valve number. With valves located between intersections, the listing may be I-20-4-I-21. Hydrants can be numbered by assigning odd numbers, leaving the even numbers for future installations in the same area. Thus, the sequence of the numbers is not destroyed.

Seasonal Advantages

When a valve or hydrant inspection program is to be performed, it is important to determine the most favorable season; this is particularly true when inspecting hydrants. Where possible, a fall inspection is best because the period of greatest activity for the water works is past, and the neglect of hydrants and valves during that time will mean that a number of items need attention.

This is also a period when many water works systems experience a decline in consumption and the necessary flushing during inspection is not apt to be a hardship on an already low supply. In freezing climates, the approaching winter demands that certain precautions be taken. The fall is therefore a logical time.

On the other hand, there are those who would favor a spring inspection because of the cracked barrels resulting from severe frosts. It is a matter of climatic conditions and the experience of the management which season he selects for the program.

There is no particular seasonal advantage for valve inspections, except that frozen ground occurring in the dead of winter makes access to the valves difficult.

Experience has indicated that valve inspection and hydrant inspection can go hand in hand and, although this may slow the program temporarily, time will actually be saved in record filing and maintenance work.

Assigning Work

Routing a proposed program will entail some study of the layout of a city or town. The use of a grid system is helpful. At Alexandria, a comprehensive master map represents the entire distribution system; eventually there will be a 36-in. by 24-in. numbered sectional plat for each grid section on this comprehensive map. A crew is assigned to each grid, and the foreman is issued file cards showing the valves and hydrants located within that grid.

It is sometimes difficult to find a crew available to devote the necessary time to this program, especially when it is to be done in a rapidly expanding system and one in which personnel are already at a premium. Here again, it is felt that the fall period helps alleviate the problem because extensions and jobbing taper off, making available crews which would otherwise be occupied with other jobs. Also, as suggested above, the program ranks in

importance with any other work even if it is necessary to postpone that other work in order to accomplish the inspection at the time required.

It is important that only those crews (and preferably construction crews) that are entirely familiar with the distribution system be assigned maintenance work. Such a crew is equipped for emergencies which may arise during various phases of maintenance. If it is necessary to use a light crew, such as one ordinarily occupied with jobbing work, it is expedient to have major repairs handled by the heavy construction gangs.

Once a crew has been chosen for the work, has been instructed in the plan of operation, and has been equipped with necessary card, plats, and other items, it will be required to ferret out the signs of trouble and take care of necessary maintenance as classified below.

Valves

The use of dissimilar metals in water works components has resulted in one of the most serious distribution problems—that is, corrosion. The practice has been somewhat curtailed, but it still exists and much research must be done before the problem is totally overcome, although there is some doubt of its ever being completely eliminated.

As is commonly known, this type of corrosion is caused by an electrolytic current established between metals of different properties suspended in a solution—in this case, the solution is water. Such a current causes an exchange of ions between metals, which builds a deposit on one or the other.

The rate of deposit or effect, of course, depends upon the chemical content of the particular water, but some action is necessarily always present, and, over a period of years, will begin to take its toll on the moving parts of valves and hydrants, particularly so when these moving parts have not been disturbed for some time. It is, therefore, one of the prime purposes of the inspection program to move these parts and to maintain the clearance necessary for ease of operation.

It is sometimes effective to obtain a washing effect on valve gates by closing a downstream valve and opening an adjacent hydrant, thereby allowing water to rush past the opening gate and the seat. This method of washing can also be advantageous in clearing hydrant valves.

In operating valves, the number of turns should be noted and compared with the record to determine if complete operation is available. At the same time, stuffing box leaks will be apparent and, although a leak during operation does not necessarily present a serious problem, a continuation of the leak after operation indicates crystallized or worn packing, or the presence of corrosion particles in the space around the stem and the stuffing box.

It is important to note here that many of the valve manufacturers now produce a valve which utilizes the O–ring stuffing-box assembly. While this cannot be considered an answer to all problems, it does appear to have advantages over the conventional stuffing box.

Bent stems can also be detected and, with careful operation it can be checked to determine if the bend is too great to leave the stem in service or if the stem is capable of passing a complete cycle. Under no circumstances should a valve be operated with sufficient force to twist the stem. Where such force is apparently needed, it is obvious that the gate is frozen or that some other

malfunction is present and that a correction must be made.

There are a number of mechanical devices for the opening of valves, which not only will relieve personnel of the tremendous strain of hand-opening, but, by virtue of a torque limiter incorporated in the mechanism, will prevent undue twisting of the stem. Such devices are highly recommended, particularly for use in a program of the type described here.

Left-handed valves in a generally right-handed system are not only disastrous in emergencies, but can be continual sources of trouble, especially when their existence is unknown by personnel. The safest method of dealing with these misfits is to get rid of them immediately. If it is impossible to remove such a valve, the only alternative is to mark it plainly for operators. This can be done by painting the underside of the box cover on mainline valves a distinctive color. Vaulted valves of such character may be painted on the operating nut or gate housing. Otherwise undiscovered left-handed valves may show themselves by displaying the same symptoms caused by deadends: recurring dirty water, lowered flows, and loss of head.

An inspection program such as the following will sometimes disclose the presence of a left-handed valve: Flow-tests on hydrants may indicate a considerable loss of head or flow in what should normally be a high-flow section. If a check then shows all known valves to be open, there is a possibility that one of those valves is left-handed. If none of the known valves is left-handed, it would be wise to start digging for valves long since buried and forgotten.

The digging, of course, should not be haphazard. A systematic closing and opening of various valves will probably narrow the location to within a few yards.

Once a left-handed valve is found, it should be removed and destroyed so that it will not be sold to another system by mistake or put back into the original system by an unsuspecting foreman. What is monetarily lost by a destroyed left-handed valve, is more than gained by savings in salaries and property protection.

Some of the greatest problems for water works personnel seem to arise from street improvement programs, drainage programs, and street maintenance. While there is no contention that such work must not go on, the author believes that there is too little cooperation between municipal departments and contractors. Valve boxes, hydrants, hydrant valves, and hydrant laterals seem, in the minds of these agencies, objects for annihilation. On the other hand, it is felt that if the water works personnel were to take more time to make the problem known to the contractor and other departments—in other words, if they were to practice a little education—this problem would be reduced to a minimum.

At Alexandria, a cooperative plan has been developed by which the engineering department passes on to the water department copies of proposed paving plans, with letters of transmittal, in ample time for crews to be scheduled for "checking out" the particular job. This plan not only prevents costly damage but results in keeping relations and tempers on an even keel.

Such "checking out" consists of adjusting mains, services, valves, and hydrants to proposed grades and, at the same time, replacing worn out or

inadequate components and adding necessary preliminary work for future expansion. During the time that the paving work is in progress, in the event that there is any uncertainty on the part of the contractor regarding installations, the assigned foreman maintains surveillance of that job.

It is also the policy at Alexandria to have the foreman, by means of his daily check slips, report any irresponsible damage by the contractor, the subsequent repair of which is then billed to the contractor and submitted prior to the time of final approval of the paving contract. Such action has considerably cut the expense of damage. Routine street maintenance apparatus, specifically the "scythe" of the road scraper, is very destructive to valves and hydrants, particularly where the road bed has been dressed to the top of a main which was never buried deeply enough. This is a problem which is not easily handled and about all that can be said of it is that an effort should be made to educate the street department crews against avoidable damage and to take whatever other preventive and corrective measures possible.

Where mains are known to be close to the road surface, or where hydrants are known to be vulnerable, it will behoove the manager of a water works to see that such conditions are remedied.

Hydrants

Fire hydrants, if properly maintained and given occasional inspections, need give little trouble to a water works. They can be equally as cantankerous as valves, however, and certainly more hazardous if allowed to go unattended.

Many people are given to thinking that because a fire hydrant is used infrequently, it will remain flawless and always ready to serve. This is false, of course, and any operator who justifies his poor hydrant maintenance and inspection program on this basis is fooling no one but himself. Obviously, moving parts need to be moved in order to keep them in good shape. Corrosion of such moving parts has already been discussed and what is true of valves is equally true of hydrants. A buildup of corrosive particles on the operating mechanisms can seriously hamper operation of the valve stem, and such hydrants are much worse than none at all.

During an inspection of hydrants, visual evidence of leaks at the hose and steamer nozzle will immediately indicate that something is wrong. If it is then determined that the valve is closed tightly, there is possibly a damaged seat or valve or something lodged between the seat and valve leather. If it is the latter it can be corrected, damaged leather excluded by completely opening the hydrant, with the additional aid of a wash effect as described previously. A damaged valve, however, necessitates the pulling of the hydrant and replacement of the damaged part.

In such cases it is well to have a new or reconditioned hydrant available for replacement so that the location will not be left unprotected. The pulled hydrant should be returned to the shop and repaired as soon as possible, as it is unknown when that very hydrant will be needed again.

When repairing the hydrant, all worn parts should be replaced immediately ignoring the possibility that a little more service can be got from them. Replacement cost is not pro-

hibitive, and will save many times the cost of another pulling within a short time.

Points to check are the stuffing-box packing, valve, valve seat, barrel (for cracks) opening of the drain port, elbow threads, geared opening mechanism, and gaskets—the methods used depending upon the make of the hydrant.

In the field, loose nozzles must be checked. They may need releading or caulking. A worn pentagon nut on a valve stem, or nozzle caps must always be replaced. On that point it should be considered a cardinal offense for any water works employee to use a pipe wrench or any other wrench to open a hydrant unless that wrench is specifically made for the job. Even the adjustable type of hydrant wrench used by many cities should be avoided, because such wrenches go out of adjustment before use and cause slipping and resultant rounding of the corners of the nut. At Alexandria, a wrench with a pentagon socket has been made to order to fit all hydrants within the city limits and within the Alexandria Area Water District; these hydrants must and do conform to city specifications on all phases of installation. Lubrication of the operating nut and of nozzle threads must be done on each hydrant, and proper entry must be made on the hydrant field card. It is also a good idea to carry spare nozzle caps to replace those removed or damaged.

Frequently, the chain holding the cap to the hydrant has a tendency to lock on the cap. One can readily see the trouble this causes when a fireman attempts to spin the cap off; he finds himself twisted in a tangle of chain or working against a nozzle cap that will not move at all. It is therefore advisable to check each chain for free action and, if necessary, to spread the cap loop to assure it.

Street-watering crews should be educated in the care of hydrants. As street flushing is a necessary evil, it is sound logic to instruct the crews how to open and close the hydrant and to request that reports be made of any hydrants needing attention.

Certain hydrants should be designated for the flushers' use, and only those should be used. Dead end hydrants are ideal for this purpose and they should be used wherever possible.

Because minor repairs can be made in the field, crews should be instructed to carry sufficient supplies to make them, thus avoiding unnecessary trips to the warehouse. Nozzle caps, stuffing-box packing, and operating nuts can always be used. The location of a hydrant should be noted with reference to a curb line, property line, telephone poles, buildings, or fences. Any obstruction to proper operation of the hydrant should be reported, in order to correct the situation.

Occasionally, a fence may be strung across a hydrant, the owner allowing for the hydrant by cutting the fence to its shape. In such a case, it is necessary to determine who is responsible for the property violation, handling the entire matter with discretion.

Hydrants vulnerable to traffic should be relocated, preferably during street-paving or main lowering. In this way it is not an excessive financial burden. Those hydrants that are particularly vulnerable, however, or those with a long record of "hits" must be moved on an emergency basis. During the relocating process it is a good idea to replace 4-in. hydrants with those having 5¼-in. valve openings. The fire

underwriter's board will eventually recommend this replacement anyway.

Stopped drain ports can cause a great deal of trouble, especially in freezing climates where water which cannot drain from the barrel may freeze and cause a crack above the frost line. Use of gravel bed beneath and around the drain ports will aid in preventing stopped ports.

Although painting cannot be conveniently made a part of inspection programs, it will be well to note hydrants specifically in need of paint. At Alexandria, painting is done in the spring. Every hydrant is thoroughly brushed, cleaned, and given a new coat of paint, using yellow for all but the bonnet, which is painted red, orange, or green, according to the delivered capacity. As a part of city specifications, the hydrant supplier ships all hydrants with an overall coat of yellow. This serves a double purpose: first, the newly installed hydrant is easy to see, which is sometimes a problem in new developments, and, second, the city is left with only the bonnet to paint.

Conclusion

As a conclusion to this discussion, it should be stated that, regardless of which phase of a maintenance program is being considered, public relations must never be overlooked. Not all homeowners are pleased with the appearance of hydrants in their front lawns, even though they are for their protection. In addition, therefore, to being kept in a good state of repair, hydrants should always be erect, correctly faced, and clean.

Reference

1. Recommended Practice for Distribution System Records—AWWA C900. Am. Wtr. Wks. Assn., New York; *Jour. AWWA*, **32**:181 (Feb. 1940).

Meter Maintenance in St. Louis County

Frank E. Dolson and E. Oliver Norman

A paper presented on Apr. 6, 1956, at the Kansas Section Meeting, Topeka, Kan., by Frank E. Dolson, Supt. of Distribution, and E. Oliver Norman, Engr., both of the St. Louis County Water Co., University City, Mo.

IT may be said that at present there is a trend toward metering in the water utility field. Many cities, some of them as large as Philadelphia, are currently engaged in extending their metering or are planning to do so in the very near future. Others, for a multitude of reasons which are not always valid, do not have plans to install meters but would like to do so. There are few cities, if any, which are deliberately embarking on a program of meter removals.

When a trend is in progress, there are usually substantial reasons behind it. In the case of meters, the reason for the trend is obvious to those responsible—meters provide revenue. They prevent unnecessary loss of water and provide good data that facilitate system design. If metering, then, is good business, the corollary is that it is also good business to purchase meters for a long-term investment and to maintain those meters in the best possible condition.

The importance of metering was recognized by operators at an early date. Water works literature is full of articles describing in great detail all aspects of the metering problem. But the end is not in sight, and certainly it should not be, considering the new developments which are constantly occurring and the great importance of metering to the water works system. Recurring problems require constant consideration. This is a fact in most lines of endeavor and certainly is applicable to the problem of maintaining water meters.

Utility metering is unique. This may seem a strange statement, considering that there are so many utilities and so many utility meters. The quality that makes utility metering unique, however, is the number of meters involved. In utilities, one meter is required for each customer; in most other businesses many customers are generally served by a single measuring device, whether it be a liquid meter, a scale, or some counting mechanism. Each utility customer is provided with an individual meter and each utility customer expects and has the right to demand that the device used for measuring his service be accurate within prescribed limits. This customer right makes it mandatory that utilities exercise care in meter maintenance and meter-testing programs. Because of the low net sales per customer compared with other industry metering and measuring devices, the economy of the matter requires a sturdy and reliable water meter which does not need frequent maintenance.

Types of Meters

Positive-displacement meters are generally used for measuring customer

service. The water works operator is fortunate in that there is a large selection of good meters available at competitive prices. The Association, by its specifications and the manufacturers and utilities, by mutual cooperation, collaborated to the end that the water meter in general is an efficient device, rugged in construction, low in initial cost, accurate in registration, and economical to maintain.

The quantity of meters produced makes it necessary that mass production manufacturing methods be employed. Mass production is a common term used for describing a manufacturing process based upon interchangeable parts. Components are made to tolerances which are close enough to allow interchangeability. In some cases, tolerances are sorted, with the final assembly being made on the basis of selective tolerances. Because of the close tolerances used, meters, as manufactured, are accurate in low-flow registration. Maintenance shop employees who are familiar with the method of manufacture, and employ proper maintenance techniques and procedures, can produce repaired meters that compare favorably with new meters in low-flow accuracy.

If the meter is sized correctly for the service conditions and if it is installed properly, a utility having a reasonable preventive maintenance program should enjoy minimum meter maintenance cost with maximum water sales.

Meter Maintenance Program

A meter maintenance program must be routine, not haphazard. To be routine and yet be economical, the program must be planned, and each stage carefully analyzed.

A meter maintenance program must include the following:

1. A policy which allows the purchase of a good meter suitable for its intended use (standardization, while not mandatory, is certainly desirable from the aspect of cost)
2. Proper meter shop layout and equipment
3. A routine maintenance system
4. Standards of repair and testing.

The principles of maintenance are the same for meters of different manufacture, although the details may vary because of the different design. The maintenance practices which will be described are those now being employed by the meter shop at the St. Louis County Water Company.

Many of the principles employed at St. Louis County are the same as those used in other shops of a similar size. Some of the details are different and there are few innovations. There are also some deficiencies, but the shop layout and equipment have been given the consideration they deserve and the maintenance program has been laid out in such a manner that, procedurally, it is routine.

The St. Louis County Water Company serves some 125,000 customers, including one intermittent and three full-time wholesale municipal accounts which constitute an additional 13,000 individual consumers. There are 121,784 meters in service in the system, with only 36 permanent accounts unmetered. The balance of the current customers is made up of homes under construction, with temporary flat-rate accounts, fire protection service on a rental basis, and similar accounts.

The area served is essentially residential although, as industrial sites in the city become harder to find, more

and more industries are to be found within the service area.

Of the 121,784 meters, 118,266, or 97 per cent, are of the $\frac{5}{8}$-in. size; 2,038, or 1.5 per cent, are $\frac{3}{4}$-in. The remainder, or 1.5 per cent, are 1-in., $1\frac{1}{2}$-in., 2-in., 3-in., 4-in., 6-in., and 8-in. meters.

Of all the meters owned, 123,500, or almost 98.5 per cent, are made by the same manufacturer. Such standardization is important from the maintenance point of view because parts inventory can then be held to a minimum and parts storage can be reduced to the smallest dimensions. Repair procedures best adapted to the kind of meter selected can be standardized. Even the low-flow accuracy test can be standardized, which is not always possible when many different makes of meters are involved. Personnel quickly becomes familiar with the one type of meter and are more quick to recognize any idiosyncrasy it may have. Then too, familiarity enables personnel to speed the meter through the shop in less time. It results in fewer rejects by the test bench. Only one type of each item of repair equipment need be provided, rather than a different type for each meter of different manufacture. Standardization facilitates the maximum production at the least cost.

Proper Equipment

Facilities and equipment play an important and necessary part in any meter maintenance program. While it is possible to maintain meters with only a few tools, antiquated equipment, and inadequate quarters, proper maintenance cannot be done economically or consistently under such conditions.

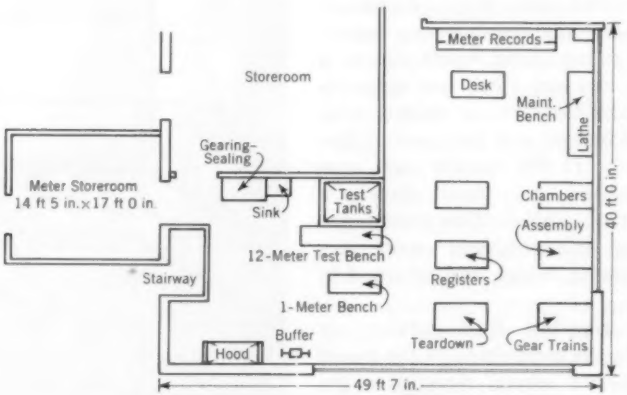


Fig. 1. Layout of St. Louis County Meter Shop

When laying out a meter shop or remodeling an existing shop, atttention should be given to the flow of material through it. In a manufacturing plant, much time is spent in designing the "flow sheet." The flow sheet of a meter shop is important, too. Meters should pass through the shop with the least amount of handling, and no "leap-frogging" or "back-tracking." Testing, disassembly, repair, reassembly,

and final testing should be progressive and orderly.

Work benches should be provided and arranged so that the entire function to be performed at that station can be accomplished without moving away from the bench. Each bench should be equipped with an electrical outlet and compressed air. Necessary tools and parts should be no more than an arm's length away.

The layout shown in Fig. 1 was designed in 1948. At that time there were approximately 70,000 meters in the system, with 4,000 new meters being installed each year. Exclusive of new meter sets, the shop was repairing and testing about 8,000 meters a year. At present there are approximately 122,000 meters in service, with about 9,000 new sets per year. Approximately 11,000 meters are now being repaired and tested during a 1-year period. All of these meters are not being disassembled; some are merely cleaned, tested, and returned to service.

Meters removed from service are received in the shop through the meter storeroom and moved directly to the test bench. Following testing, they are moved on racks to the teardown bench. From there the cases and register covers are taken to the brushing and chemical-cleaning area, and the registers, chambers, and gear trains go to their appropriate repair bench as labeled. Following cleaning and repair, these component parts are brought together again at the assembly table, and from there are taken on racks to the test bench for an "outgoing" test. Meters which meet repair standards are then geared and sealed, followed by storage in the general storeroom prior to being returned to service. Rejects are returned to the repair cycle at the assembly table.

Tools and Equipment

A meter test bench is fundamental, as are calibrated tanks or tanks mounted on scales, rate of flow indicators, test dials, and other meter test bench appurtenances. Other equipment not associated with the test bench should also be provided.

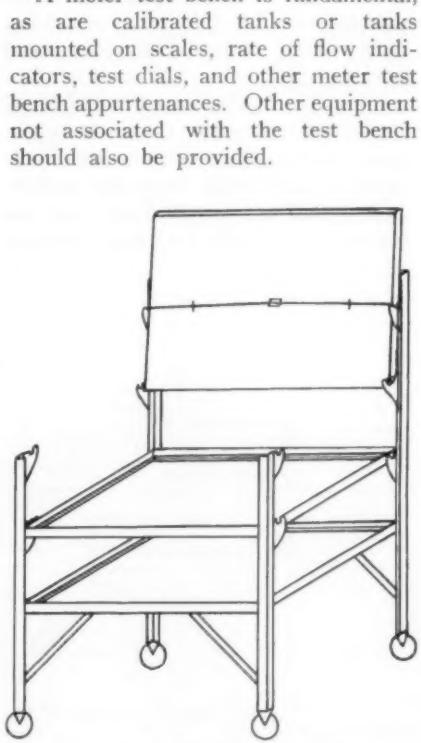


Fig. 2. Tote Cart for Meter Shop

Surface area of the top is 24 in × 34 in., and the cart is 38 in. high.

Sturdy work benches for each operation are a necessity, and they should be individual, if possible. Tote racks, or some other means of stacking and transporting the meters, are required.

The tote rack illustrated in Fig. 2 and 3 is a versatile piece of equipment which has become almost indispensable at the St. Louis County meter shop.

As shown, the top two shelves or trays are suspended by a pivoting arrangement which allows them to be either folded up or removed to allow access to the next lower shelf. A simple locking device holds each shelf vertical when not in use. Each shelf is 34 × 24 in. and holds eighteen meters. By using large 3½-in. ball-bearing casters, 54 meters can be transported readily to any point in the repair process.

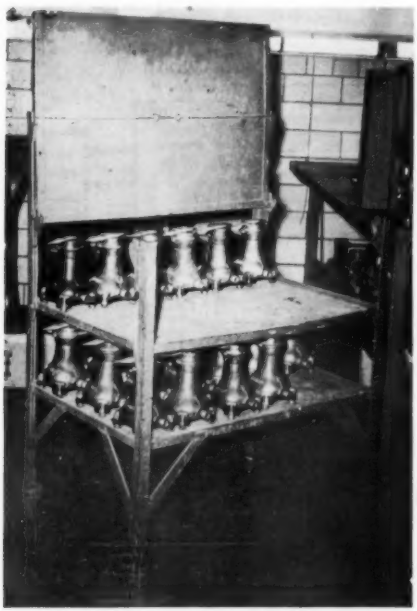


Fig. 3. Tote Cart in Operation

Hand tools, torque wrenches, a portable drill, drill press, bench lathe, tap and die sets, a rotary brush mounted on a flexible shaft, power brushes equipped with a dust-collecting system, and acid and caustic baths located in a hood properly vented to atmosphere may also be needed, depending upon the shop. Hot water is a must when any type of chemical cleaning is done.

With labor costs being what they are and competition for mechanics being extreme, tools and equipment of the right kind and at the right place are essential. Minimum equipment may result in greater cost.

Routine Maintenance

As has been said, a maintenance program must be routine to be effective. There must be a procedure or plan to follow. This involves paper work and record keeping that cannot be avoided. There must be an individual permanent record for each meter. It may be a simple 3 × 5-in. card, or it may be an elaborate form where space is provided for recording each operation performed on the meter.

The elaborate system involves considerable clerical work, but it does concentrate necessary information on a single record sheet for each meter. The minimum system, as used in St. Louis, shows only the meter number, the date set, and its location by an account number system. Although this system has been reduced to its bare essentials, it provides whatever data may be required. It consists of [1] meter set, remove, and change order tickets; [2] permanent record card; two-part tag for incoming meters; and [3] repair card for outgoing meters. The routing of the meters and various cards is shown in Fig. 4.

With this system, one man devoting not more than 5 hr a day can handle the record keeping for a throughput of 12,000 meters per year. He can instantly tell the location of any meter in the system, and routinely informs the billing department of any incoming

meter testing outside of prescribed limits in order that proper adjustments can be made in the billing. Upon request, he can supply registration accuracy data on any meter in use. If a meter is lost or misplaced, the information will be available at the end of the day.

Routine meter changes conform to the requirements of the Public Service Commission. Changes are made according to the following schedule: $\frac{5}{8}$-in. meters, oil enclosed, after 200,000 cu ft or 10 years; $\frac{3}{4}$-in. meters, after 300,000 cu ft or 8 years; and 1-in. meters, after 400,000 cu ft or 5 years. For $1\frac{1}{2}$-in. meters or larger, changes are made after 4 years of service.

At St. Louis County it is now necessary to make 10,000–12,000 meter changes each year if there are to be no meters in service beyond limits specified. This results in a large work load, not only for the repair shop but also for the service men. In order to distribute the load evenly throughout the year, 10-year change tickets are issued daily to each service man. These are worked as it is convenient to do so or as a way of filling out the work day.

Meter Maintenance

The scheme for repairing water meters has been reduced to a definite procedure having the following steps:

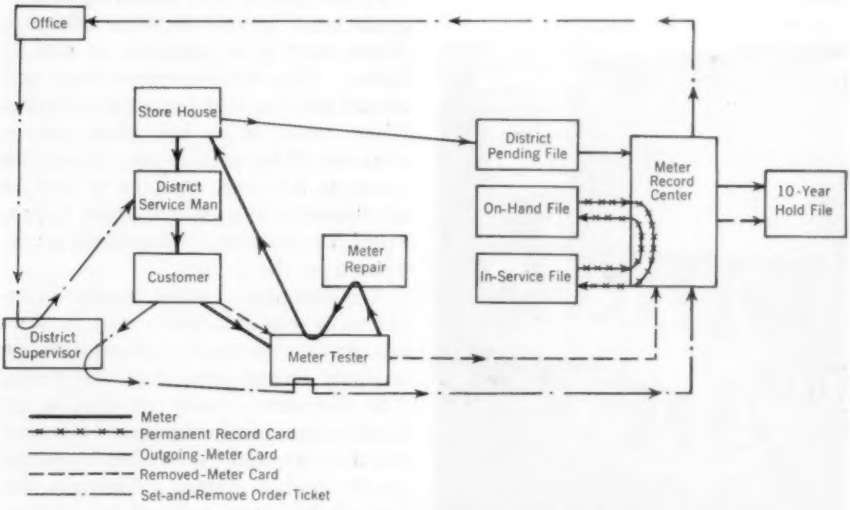


Fig. 4. Routing of Meters and Record Cards

1. All incoming meters are tested for accuracy at low flow and at the gearing point.

2. Meters that test below standards are sent to the disassembly bench. Meters with accuracy better than the minimum requirement are cleaned and made ready for reuse as a repaired meter.

3. In disassembly of meters, use is made of the principle of interchangeability. Component parts are sorted by kind—that is, all registers in one container, all gear trains in another.

The only exceptions to this rule are the chamber and disc, which are kept as a unit because the manufacturer assembled these on the basis of using selective tolerances.

From time to time, as warranted by either quantity or need, a repair man overhauls components of the same type that have been accumulated. That is to say, a large number of registers are repaired, then trains, and then chambers and discs are refitted.

Cases are cleaned and brightened in batches by brushing and dipping in an acid or caustic bath. Bottom bolts or other fasteners are cleaned either by dipping or by placing them in a tumbling machine.

Repaired and cleaned parts are kept sorted by types in containers. At the assembly bench, all components are available within an arm's length to the assembler. With this method of repair and assembly there is little likelihood that a component part ever finds its way back to its original case. It would be the sheerest accident if it did.

The proof of whether a meter has been repaired properly is determined at the test bench, where it must pass the minimum-flow tests. The registration at the intermediate flow of repaired ⅝-in. meters must be not less than 98.5 per cent nor more than 100.5 per cent when using change gear combinations that are more than 0.3 per cent faster than those specified by the manufacturer at the gearing point.

Test bench rejects can be reduced by a mechanic with a good feel for fitting the disc and the chamber. A "go–no go" gage is very helpful. Care in positioning the disc spindle in relationship to the control block has a material effect upon meter accuracy and, if properly done, will reduce low-flow rejects. Typical gages are shown in Fig. 5 and 6.

Test standards are necessary in any meter maintenance program, and they can be set at a high or low level. If set low, there will be fewer meter rejects, but the ratio of meter sales to water pumped may also be low.

The test standards used at St. Louis County are given in Table 1.

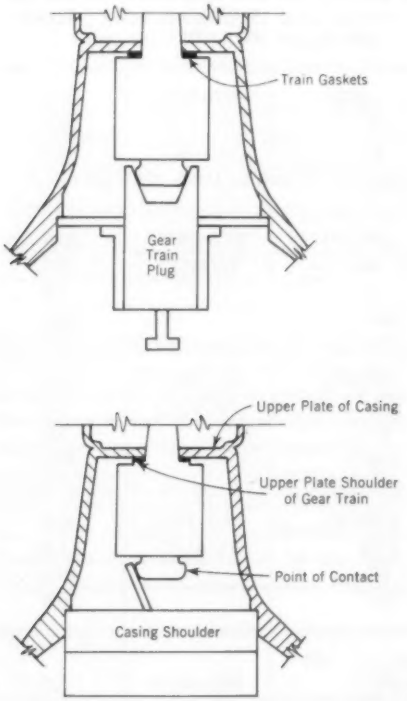


Fig. 5. Gages for Positioning Meter Parts

The gaskets shown for adjusting are lead train gaskets of 0.01-in. thickness. The gear train plug shown in the top figure must be level with false chamber surface.

Conclusion

Using the routine maintenance repair procedures and standards de-

TABLE 1

Meter Department Standards *

Type of Meter	Rate of Flow *gpm*	Accuracy Required *per cent*	Test Quantity† *cu ft*
$\frac{5}{8}$-in. repaired meter	10		5.0
Trial gears	2(GP)	98.5–100.5	1.0
(6 spindle) R33 $d=0.770$; SB24 $d=0.570$ / (7 spindle) R33 $d=0.860$; SB24 $d=0.670$	$\frac{1}{8}$	60(AGC)	0.1‡
	(Preferable not to gear over 100 per cent.)		
$\frac{3}{4}$-in. repaired meter	3(GP)	98.5–101.0	2.0
Trial gears	15		5.0
R20 $d=0.77$; SB21 $d=0.77$	$\frac{1}{8}$	65(AGC)	0.1‡
	(For 98.5–99.0 per cent with trial gears, add 0.5 per cent by using 18–19 combination. Preferable to gear 100.5–101.0 per cent.)		
1-in. repaired meter	4(GP)	99.0–101.0	5.0
Trial gears	20		10.0
R47 $d=1.166$; SB13 $d=0.354$	$\frac{3}{16}$	70(AGC)	0.5‡
	(Preferable to gear to 100.5–101.0 per cent.)		
1½-in. repaired meter	50(GP)	98.8–99.9	20.0
Trial gears	0.4	70(AGC)	0.5‡
R36 $d=0.86$; SB26 $d=0.67$	5		5.0
	100		30.0
2-in. repaired meter	60(GP)	98.7–99.9	30.0
Trial gears	$\frac{7}{16}$	70(AGC)	0.5
R24 $d=0.67$; SB32 $d=0.86$	12		5.0
	120		30.0
3-in. disc meter	130(GP)	99.0–100.5	40.0
Trial gears	1–1½	70(AGC)	1.0
R35 $d=0.86$; SB28 $d=0.67$	10		10.0
	75		30.0
3-in. compound meter	(*a*) 10(GP)	(*b*)	98.8–101.0 / 5.0
Trial gears	0.3		70(AGC) / 0.5‡
(*a*) 1-in. disc section: R47 $d=1.166$; SB13 $d=0.354$ / (*b*) 3-in. crest section: R24 $d=0.67$; SB32 $d=0.86$		130(GP)	98.8–100.0 / 50.0
		90	40.0
		50	30.0

TABLE 1 (*contd.*)

Type of Meter				Rate of Flow *gpm*		Accuracy Required *per cent*	Test Quantity† *cu ft*
3-in. crest meter				140(GP)		98.8–100.0	50.0
Trial gears				7		70(AGC)	5.0
R24		SB32		20			10.0
$d=0.67$		$d=0.86$		75			30.0
4-in. compound meter				(*a*) 10(GP)	(*b*)	98.8–101.0	5.0
Trial gears				0.3		70(AGC)	0.5‡
(*a*) 1-in. disc section		(*b*) 4-in. crest section					
R47	SB13	R22	SB44		130(GP)	98.8–101.0	50.0
$d=1.66$	$d=0.354$	$d=0.52$	$d=1.007$		90 50		40.0 30.0
4-in. crest meter				140(GP)		98.8–101	50.0
Trial gears				9.0		70(AGC)	5.0
R22		SB44		75			30.0
$d=0.52$		$d=1.007$		25			20.0

* Letters used in this table indicate the following: R—register; SB—stuffing box (the numbers following R and SB indicate the number of teeth on the gears at the register and stuffing box, respectively); *d*—diameter of the change gears, in inches; GP—at gearing point; and AGC—after gearing change.
† Test quantities are computed by weight unless otherwise indicated.
‡ Test quantity is computed by volume.

scribed, water sales of 88–90 per cent of the water pumped have consistently been achieved. Under-registration of the meter is not the entire story when reducing unaccounted-for water to a percentage figure. Main breaks, joint leaks, authorized and unauthorized use of water from fire hydrants, and under- or over-registration of the system's input meters also play an important part. But the effect of under-registration of customers' meters on the sales-pumpage ratio should not be underestimated.

Meter registration means water sales. The ratio of water sold to water pumped is a measure of performance and a good maintenance program will help in maintaining that performance at a high level.

Automatic Controls in Filter Plants

Milford E. Rogers

A paper presented on Mar. 21, 1956, at the Illinois Section Meeting, Chicago, Ill., by Milford E. Rogers, Mgr., Project Eng. & Sales, Builders-Providence, Inc., Providence, R.I.

AUTOMATIC control is no newcomer to our age, but it has received great popular appeal lately under the name of "automation." By automatic control, we strive to simulate mechanically what an experienced man would do if he were trying to watch a level gage and manipulate a valve controlling the level at the same time. Such an arrangement is shown in Fig. 1. The closer the control, the more exacting and tedious is the task. By placing a float in the tank, the need for the man is eliminated and automatic control is achieved (Fig. 1). The float is attached to a lever which, in turn, rests on a fulcrum and is connected, through proper linkage, to the valve. As the level lowers, the valve opens to admit more flow, and conversely, as the level rises, the valve is throttled. An exact balance is thus obtained between outflow and inflow. This is a very simple but practical example of automatic control that has released man for other, more important duties. The float and lever system has no "brains" but does the job better, perhaps, because it is not subject to common human faults.

Hydropneumatic Control

In the example just cited, the linkage between the float, or level-sensing element, and the valve was mechanical. Systems to accomplish the same purpose are available with hydraulic, pneumatic, or electrical linkages. A typical hydropneumatic (hydraulic-pneumatic) system is shown at the bottom of Fig. 1. Here, change in the level is converted into an air signal which is transmitted through a small-diameter air line to a positioner mounted on the valve. The positioner is mechanically linked to the movement of the valve so that the position of the valve is "fed back" into the positioner and "matched" against the air signal from the level transmitter. There is, therefore, a corresponding position of the valve for each position of the water surface. In control jargon this is termed "proportional mode."

In a conventionally designed water treatment plant the flow of water may be regulated automatically. Figure 2 shows one method of accomplishing this. A pneumatic level transmitter senses the level in the clear well and applies a proportional air pressure to the rate-setting device on the individual filter effluent controllers. This causes the controllers to throttle in proportion to the clear well level and thus follow the demand.

In true automatic control, the result of an operation is measured, transmitted, compared to a standard, and used to correct or control the operation to produce the desired result—self regulation. Various degrees of automatic control are possible, depending on the control components utilized and the results desired. More information

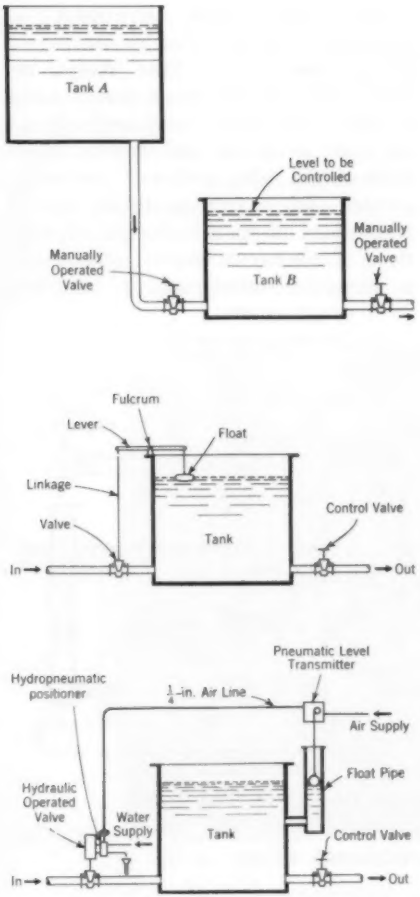


Fig. 1. Types of Control

In the upper diagram, the level in tank B is controlled by means of a manually operated valve. The middle diagram shows a basic type of automatic control. The float is attached to a pivoting lever which, in turn, is linked to the influent valve. In the lower diagram, a hydropneumatic level control has been substituted for the mechanical link. The air line transmits changes in level to a positioner linked to the valve.

is available in the literature of this field.

Automatic Backwash Control

The one phase of filter operation that has been given very little attention in the "automation" literature is automatic backwash control. Backwashing filters automatically or semiautomatically is not new. A number of designs have been used for some time on pressure filters and ion-exchange or demineralizing beds. Eric Denholm recently reported on an automatic backwashing system constructed for the Stirlingshire and Falkirk Water Board in Scotland (*1*).

One of the earliest modern automatic backwashing systems was installed in 1948 at the Occoquan filter plant of the Alexandria Water Company in Alexandria, Va. This installation, featuring many cost-saving innovations, was reported by Aldrich (*2–4*).

In the automatic backwash control system, each filter is fitted with a program timer energized by the plant attendant. A signal lamp and alarm system, tied in with each filter loss-of-head gage, notifies the operator that a given filter needs backwashing. The program timer contains an adjustable cam for each main valve. The valve-operating sequence is conventional (close influent, close effluent, open drain, and open wash). After the backwash water has been applied for a predetermined duration at predetermined rates, the valve sequence is automatically reversed. The drain valve is closed, the wash valve is closed, the influent valve is opened, and finally the effluent valve is opened, returning the filter to operation. A time interval is provided between the closing of the

influent valve and the effluent valve to permit the filter to drain down. Similarly, a time interval is provided between the closing of the drain valve and the wash water valve to fill the filter to proper operating level.

Backwash Rates

Backwash rates are regulated by means of a standard flow controller protecting the filter bed from an accidental excessive flow. Three backwash rates are provided in sequence: an initial low rate, the usual high rate, and another low rate. Each of these rates is independently adjusted as to both quantity and duration. The initial rate is applied to break up the upper sand crust in a gentle manner and to permit accumulations of air to escape without danger of displacing gravel layers. The usual high rate is applied to cleanse the sand grains. The final low rate is applied to prevent sudden depositing of sand—that is, to permit good sand classification.

The wash water flowmeter is equipped with a recorder having a 60-min chart drive. This drive is interlocked with the wash water valve to start the chart simultaneously as the valve is opened and stop the chart drive as the valve is closed. An exaggerated, but extremely useful record is obtained of each backwash application. Economy of charts is achieved, as many operations may be recorded on a single chart.

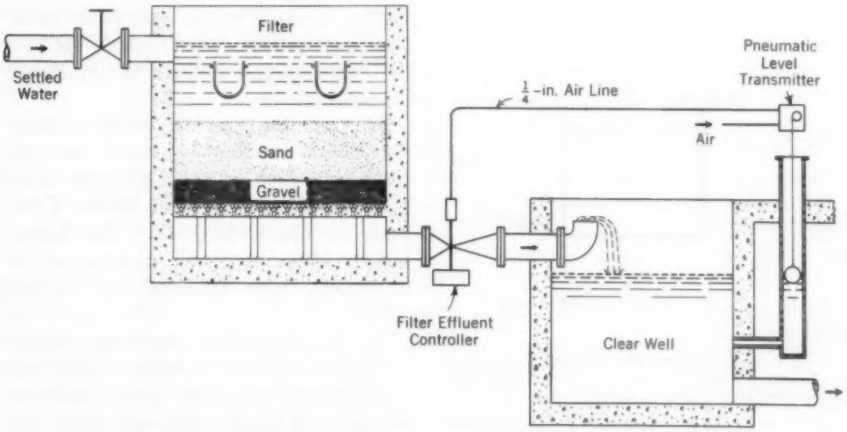


Fig. 2. Regulation of Plant Output From Clear Well Level

A conventional clear well regulator using pneumatic level transmitter to control filter effluent valve is shown.

Filters are interlocked so that only one filter may be backwashed at one time. The Alexandria plant control panel (Fig. 3) concentrates all controls, level gages, meter instruments, and valve position–indicating lamps in one central location. The filters proper are several hundred feet distant.

Air Transmission

A control concept of particular interest is the use of air transmission for metering and control. This not

only adds to convenience, but increases the reliability of the installation. An air selector switch is provided on the control panel for each filter valve. The switch has three positions: "open," "auto," and "shut." A single ¼-in. copper air line runs from each switch to a hydropneumatic valve adjacent to each main hydraulic cylinder–operated filter valve. When the switch is in an indicated position, the main valve takes a corresponding position; thus when in the "auto" position, the main valve is under control of the automatic program controller. Provision is made at each hydropneumatic four-way valve to shift and latch its position manually in case of emergency or for a test. A gang of hydropneumatic four-way valves is shown in Fig. 4.

Another provision is made at the central panel to stop the backwash sequence at any point in its progress, allowing manual operation, or to return to its initial position. Provision is also made at each filter to extend the washing period manually for as long as desired.

A similar installation to that just described has been in service since 1949 at Morelia, Michoacan, Mexico. It differs in that the central components are installed in conventional operating tables instead of the central panel board.

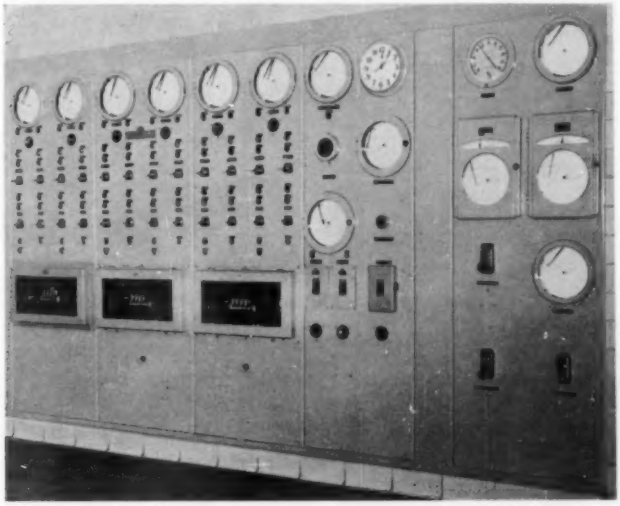


Fig. 3. Control Panel, Occoquan Station, Alexandria, Va.

The panel centralizes level and meter gages, valve position–indicating lamps, and all other controls.

Modified or refined versions of the Alexandria arrangement have been installed at Westmoreland County Municipal Authority, Greensburg, Pa.; Citizens Water Company, Canonsburg Filter Plant, Washington, Pa.; Huntington Water Company, Huntington, Va.; and Greenwich Water Company, Mianus Filter Plant, Greenwich, Conn.

Control Variations

The main difference between the Alexandria and Greensburg installations lies in the method of selecting and initiating the backwash sequence. In the former, a separate program timer was used for each filter, while at Greensburg, a single master timer transfers from filter to filter by a master selector switch. In all other respects, the operation of the equipment is identical to that previously described.

Further refinements have been evolved to simplify and improve the operation of the automatic backwash system. The master timer has been eliminated in favor of a cascading-type control in which the operation of a valve, once initiated, triggers or sets off the operation of the next valve in the sequence. Means are provided to regulate the level in the filters; to afford a delay permitting levels to lower to the desired point for application of surface wash or backwash; to permit the filter level to return to normal operating height; or to provide for a predetermined length of filtering-to-drain, where used. This type of backwash control (sequential) uses air actuation for operation of the hydropneumatic four-way valves. Modification may be made to permit the use of electrically operated valves. The backway control with electric modification * used for an AEC installation in Washington, is shown in Fig. 5.

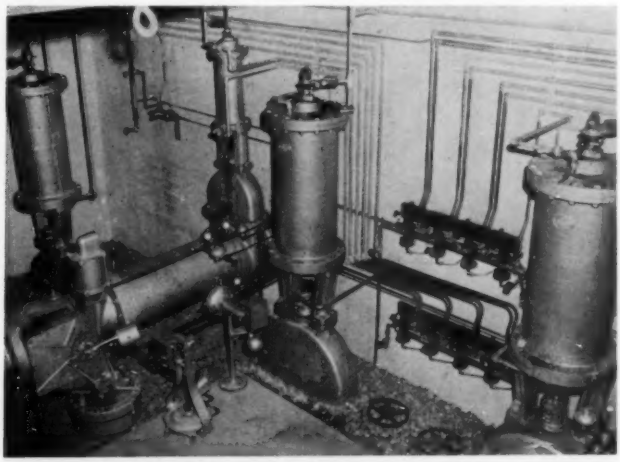


Fig. 4. Hydropneumatic Four-Way Valves

A gang of hydropneumatic four-way valves at the Westmoreland County Municipal Water Authority is shown. Note air lines from the automatic program controller in center background.

Examples of pneumatic cascade controls are in operation at the Gulf Oil

* Illustration shows Autocentral backwash control manufactured by Builders-Providence, Providence, R.I.

Company refinery at Port Arthur, Tex.; at the city of Ardmore, Okla.; at the Town of Tonawanda, N.Y.; and at the East St. Louis and Interurban Water Company, East St. Louis, Ill. A specially modified design has just been placed in service at the new Northeast Filter Plant, Detroit, Mich., for the operation of 48 filters.

Benefits

The current trend is toward simplifying operations, reducing first costs, and cutting operating expenses. The controls already described do not materially reduce first cost except in allowing structural modification which definitely reduces original construction cost. The savings in operating cost, however, can be substantial. A filter which is backwashed manually requires about 40 min of attention from an operator for the entire process of opening and closing valves, draining down, backwashing, surface washing, refilling, and, in some cases, filtering to drain for a short time. In a recent plant study involving 40 filters, assuming only 20 filters would be washed each day, it was calculated that a saving of 13.3 man-hours per day could be made (93 man-hours per week). Assuming a 40-hr week, this is equivalent to a staff of 2.3 men (including relief) which could be eliminated. Estimating each man's salary at $5,000 a year, an annual savings of $11,500 would result.

Although few plants contain 40 filters, real savings are available to smaller plants as well. Human failures which cause over- and underdosage of chemicals, upsetting filters by inadvertent application of excess backwash rates, or cracks and mudball formations permitting the pulling through of suspended materials can all be reduced by proper selection and application of automatic controls.

Future Use

More of the type controls just described may be expected to come into general use in the future. In addition, the author ventures to forecast that automation in water treatment plants will become the rule rather than the exception. Plants will be designed and built in which the application of chemicals will be determined by an automatic analyzer in the plant laboratory. This device will in turn control the addition of chemicals to produce a constant and uniform quality of water free from bacteria and other contaminants. The plant technician will

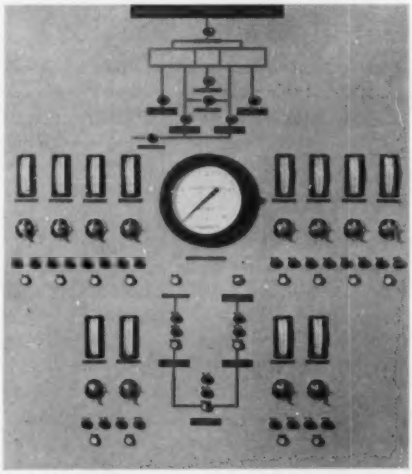


Fig. 5. Backwash Control Panel

Electric, rather than pneumatic, valve controls are used at the AEC installation in Washington.

merely set the controls to the desired final characteristics, make occasional checks in performance, order chemical supplies, and change charts. Controls based on turbidity, pH, conductivity, reduction-oxidation reactions, and chlorine residual are already in use to a limited extent and in isolated installations. It simply becomes a matter of time until technological advances supplant the present manual skills now employed.

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Artificial Recharge Through Tunnels

By George A. Whetstone

Abstract of contribution by George A. Whetstone, Assoc. Prof., Texas Technological College, Lubbock, Tex.

To counteract a continuous decline in the water table at Famagusta, Cyprus, 3.7 mil gal of lake water was discharged into six wells over a period of 52 days during the winter of 1951–52. The results were not wholly satisfactory, as the silt beds of the lake have a rather high salt content, which causes the salinity of the water stored there to rise with increased exposure. Thus, speed of recharge becomes important. To increase the absorption rate a tunnel was driven in porous sandstone, just above the water table, connecting the wells about 60 ft below the surface. The 900 ft of tunnel completed by February 1953 was sufficient to increase the water absorption to 4.5 times the rate of the previous winter. During 1953 the tunnel was extended to a total length of 1,900 ft. As between tunneling and open-pit spreading, the considerations would seem to be the same as those in the coal or metal mining industries—value of land, disposal of spoil, depth to working levels, and stability of terrain—plus ease of cleaning, because the silt inevitably deposited in pit or tunnel must be removed or at least broken by cultivation to retain surface permeability. Recharge tunneling probably merits most serious consideration in city areas where cooling water is being returned to the ground, as on Long Island, N.Y., or where treated river water at low temperature is being pumped into the aquifer, as at Louisville, Ky., in the winter. It might also find some application in areas like the High Plains of Texas, where ephemeral lakes could be drained to underground storage with the double benefit of easing the rate at which the water table is dropping and of releasing for planting the land otherwise covered by a shallow pond. There, again, speed would be important, to minimize evaporation losses and to drain the land promptly, as the rainy season and the planting season often coincide.

Eventual Effects of Faulty Pipe Laying in the Former Town of Lake, Wis.

Elmer W. Becker

A paper presented on Sep. 22, 1955, at the Wisconsin Section Meeting, Milwaukee, Wis., by Elmer W. Becker, Asst. Supt., Milwaukee Water Works, Milwaukee, Wis.

THE occurrence of breaks in water mains is not unusual. Such breaks occurred so frequently in the distribution system of the former town of Lake, Wis., however, that an investigation into the possible causes of the breaks was made. It was determined that the cast-iron pipe in the system was not at fault. Further investigation indicated that improper laying practices and temperature variations were probably responsible for the frequent occurrence of breaks.

Background

At a spring election on Apr. 7, 1954, the former town of Lake was consolidated with the city of Milwaukee, a majority of the electorate of the two governmental units voting for consolidation. Thirteen thousand people and 9.5 sq miles of area were thus added to the city of Milwaukee.

The process of consolidation also added the water utility of the town of Lake to the Milwaukee Water Works. The Lake utility consisted of two artesian wells (one 1,834 ft deep and one 1,408 ft deep), one 69-ft deep gravel-walled well, a softening plant, a 1-mil gal elevated storage tank, pumps, and a 55-mile distribution system.

This water utility had served the heavily populated portion of the former town of Lake, which comprised $\frac{1}{8}$ of the town's area and was located along the northern border of the town, immediately South of Milwaukee. In addition, the utility also served all of the city of St. Francis and a small portion of the city of Cudahy. Total population served was 18,000. St. Francis and the portion of Cudahy served by this utility were a part of Lake at the time the utility was constructed.

Construction Procedures

Construction of the Lake utility was begun in 1938, completed in 1939, and began to serve its customers officially on Dec. 1, 1939. The total cost of the original project was $1,380,000.

Cast-iron pipe for the project was Type I, Class 150, bell-and-spigot pipe, in 18-ft lengths. It was manufactured by one of the larger pipe foundries, which practices quality control. Records show that the pipe was manufactured in accordance with federal specification WW-P-421, and no defects were found in the pipe on delivery.

The original distribution system, including 41 miles of 6 in., 8 in., 12 in., and 16 in. diameter cast-iron mains, was constructed by seven crews in 100 working days, beginning the first week in April and ending in the last week of July, 1938. The work was done by one of the local public works underground contractors, under a contract let by the town board of Lake.

Inspection of the work was done by engineering students who were attending a cooperative course at a local university. These student inspectors were hired and supervised by the consulting engineer who designed and supervised construction of the water works plant.

One of the seven crews mentioned above constructed all of the tunnel work required and did not work the full 100 days on the project; another crew worked only on hydrant branch and hydrant installations, and a third crew worked only on the flushing operations, which were started late in June. This left four crews available to install all of the 41 miles of street mains, averaging 568 lin ft (including all sizes of pipe) per crew per 8-hr day. This high average was obtained by setting up competition between crews. The construction superintendent would tell one crew how much pipe another crew had laid the previous day, and the first crew would then try to outdo the other crew. Competition between crews was so successful that, in one 8-hr day, a crew installed 1,200 lin ft of 6-in. pipe. Competition of this kind does not promote good pipe-laying practice, however, as was later discovered.

Trenches for the water pipe were excavated with a trenching machine and were 26 in. wide for 6-in. and 8-in. water pipe, and 30 in. wide for 12-in. and 16-in. water pipe. The bottom of the trench was usually dug 4–6 in. deeper than the grade line for the bottom of the barrel of the pipe so that the bells on the pipe would clear the trench bottom. No bell holes were excavated because braided hemp and sulfur jointing compound were used in the joints and calking was not required.

Maple heart blocks 1–3 in. thick were used to support the water pipe from the bottom of the trench to the proper grades, as indicated on the construction plans. There were always two and sometimes three or four blocks in one support, depending upon how much deeper the trench was excavated below the required grade. The contractor's superintendent of construction stated that three supports were ordered for each 18-ft pipe length—one support 3 ft from each end and a third support halfway between the two end supports. He further stated that, because this was the first time that 18-ft pipe lengths were laid in this area, those concerned with this project felt that an extra support was needed. Previous to this time, the Milwaukee area had been using AWWA-specified Class C pipe in 12-ft lengths, with two supports per pipe length, each support being 3 ft from the ends of the section.

In general, from South Pine Avenue to the western limits of the project, all of the trenches were excavated in clay soil which varied from a soft, moderate type of clay to a hard, solid red clay, some of which was almost as hard as hardpan. The farther West from South Pine Avenue that the trench was located, the harder the clay became. This type of soil also prevails in the area South of East Bolivar Avenue and eastward from South Pine Avenue to the Lake Road. The sequence of installing water pipe in this project was from West to East—that is, the first water pipe laid early in April was laid in trenches excavated through the hardest clay found in the area.

Generally, from South Pine Avenue eastward to Lake Michigan, North of East Bolivar Avenue, 95 per cent of the trenches were excavated in a sandy gravel type of soil.

Sandy gravel backfill was used wherever trenches were excavated in traveled roadways and in shoulders of

traveled roadways. Sandy gravel backfill was placed in the trench by dumping directly from the delivery truck and was used in approximately one-half of all excavated trenches. The excavated material from these trenches was hauled from the construction site.

The excavated material was used as backfill material in the other half of excavated trenches. Most of it was placed in the trench by bulldozers, and some of it was pulled into the trench by a dragline scraper. No fine original excavated material was placed by hand shoveling either underneath, around, or over the pipe, all of this work being done by bulldozing and by dragline scraping. As a result, lumped clay fell directly on the pipe, settled by its own weight, and formed a bridging between the sides of the water pipe and the sides of the trench. This practice prevented backfilling material from filling the void underneath the water pipe.

From the first week in April until the last week in May, when a heavy rainfall occurred, 17–18 miles of water pipe were laid in trenches excavated through the hardest clay in the project. The rainfall was the first water to come in contact with backfilled trenches; other than that, the only assistance to settlement had been the natural weight of the backfilling material itself.

An additional 12–13 miles of water pipe were laid in the project from the last week in May to the last week in June. Four to five miles of pipe were laid in trenches excavated through clay soil and backfilled with clay. The first well was completed and placed in operation in the last week of June. The mains laid prior to this time were then filled, pressure tested, and all back-

TABLE 1

Annual Breaks in Pipeline

Year	Total Number	Transverse Breaks		Longitudinal Breaks	
		6 in.	8 in.	12 in.	16 in.
1940	1	0	0	1	0
1941	4	3	0	0	1
1942	7	6	1	0	0
1943	7	5	2	0	0
1944	4	1	1	2	0
1945	9	8	0	1	0
1946	9	7	0	2	0
1947	12	10	0	2	0
1948	14	11	1	1	1
1949	12	9	0	3	0
1950	12	11	0	1	0
1951	18	14	0	2	2
1952	15	10	0	4	1
1953	15	9	1	4	1
1954	19	18	0	1	0
1955*	31	27	2	1	1
Total	189	149	8	25	7

* Data for the year 1955 are for January–March, inclusive.

filled trenches were flushed by the pipe jet method.

Trench Conditions

Almost all of the breaks have occurred in the area where trenches were excavated through clay soil, and there were very few in the area where trenches were excavated in the sandy gravel soil. It is believed that the pipe, and in some places this indentation is as much as ¼ in. deep. This condition indicates that the pipe is continuously under a stress caused by trench conditions. To cause such an indentation in the block supporting the pipe at a break, other nearby supports must have settled. It is believed that some of the supports were made up of a combination of maple heart blocks

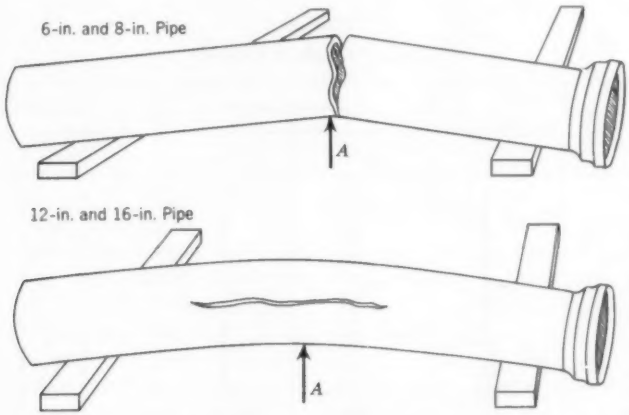


Fig. 1. Types of Breaks Found

In general, all breaks occurred as shown above: the 6- and 8-in. pipe broke through the cross section and the 12- and 16-in. pipe split longitudinally. The breaks or splits were caused by an upward force shown at A. This force resulted from uneven settling caused by loose soil under the end blocks and solid soil under the center block. The presence of a hard clay lump, rock, boulder, or sewer lateral at the center of the section had the same effect, preventing the pipe from settling as much at the center as at the ends.

rapid installation of pipe on this project is significant.

When excavating for breaks, it has been found that almost all of the breaks occur on top of or next to one of the maple heart supports. Some of these supports consist of as many as four 3-in. blocks. The block directly underneath the pipe always assumes an indentation conforming to the shape of with backfilled material under those blocks occurring where the trench was excavated more deeply under the proposed grade line.

Undoubtedly, the long delay in flushing clay-backfilled trenches contributed to faulty installations: the clay lumps falling into the trench could have bridged over the water main, hardening into position and preventing

backfill material from filling the space between the water main and the bottom of the trench. The delayed flushing probably was not sufficient to dislodge this hardened crust. It may well be that the heavy rain received late in May could have been just enough to assist in the formation of a clay crust over the water pipe before the pipe jet flushing started in late June. This condition left voids between the water main and the bottom of the trench, causing the water pipe to carry the entire backfill load between supports.

It is interesting to note the characteristic pattern that prevails wherever breaks have occurred. Eighty-five per cent of the water main breaks were in clay soil and at or near blocking points. Figure 1 shows the kinds of breaks which occurred in the pipe. Breaks in the 6-in. and 8-in. diameter water pipe were transverse breaks through the cross section of the pipe; the 12-in. and 16-in. diameter pipe split longitudinally along the long axis of the pipe. Ninety per cent of the transverse breaks opened at the top of the pipe. The following data show the occurrence of breaks in the various sizes of pipe: 79 per cent of all breaks occurred in the 21.2 miles of 6-in. pipe; 4.5 per cent occurred in 3.3 miles of 8-in. pipe; 12 per cent occurred in 12.2 miles of 12-in. pipe; and 4.5 per cent occurred in 4.3 miles of 16-in. pipe. Table 1 gives data on annual occurrence of breaks.

It is interesting to note that during the period Jan. 6–Feb. 4, 1955, the city of Milwaukee had 1 break in 1200 miles of water pipe while the former town of Lake area had 18 breaks in 55 miles of water pipe.

A summary of the construction methods used when the original mains were laid makes it apparent that the following factors contributed to placing these mains under constant stress, forcing them to act either as a cantilever or as a beam:

1. Improper use of blocking
2. Placing backfilled material under some blocks only
3. Bulldozing clay-lumped excavated material into the trench directly over the main without previous hand shoveling of fine material around the pipe
4. Waiting too long before clay-backfilled materials were flushed
5. Insufficiently excavating tunnels, leaving hard clay or hard pan in contact with the bottom of the main
6. Failing to remove rocks and boulders from contact with the bottom of the main
7. Insufficient clearance over sewer laterals.

Temperature Variations

In a properly installed pipe, the stress imparted upon the water main by the superimposed backfilling load is not sufficient to cause a break. In an improperly installed pipe, certain beam and crushing stresses occur which, by themselves, would probably not cause failure, but when temperature stresses caused by colder weather are superimposed, the additional stress causes a break; this accounts for the low incidence of breaks in the summer months and the many (82.6 per cent) in the cold months. After occurrence of 35 breaks in the period from Nov. 1 to Mar. 31, 1955, for instance, there were no breaks during the summer and early autumn of the year.

Table 2 gives data on main breaks according to the month in which they occurred. In the late fall and winter season from Nov. 1, 1954, to Mar. 31, 1955, there were 35 breaks. In the 16 years of experience indicated in Table 2, there were 8 days on which

TABLE 2

*Monthly Occurrence of Breaks, 1940–55**

Month	Number of Breaks					Per Cent of Total†
	6-in. Pipe	8-in. Pipe	12-in. Pipe	16-in. Pipe	Total	
January	38	4	5	0	47	24.90
February	37	3	1	1	42	22.20
March	21	0	0	0	21	11.10
April	4	1	1	0	6	3.17
May	1	0	2	1	4	2.11
June	0	0	3	0	3	1.58
July	1	0	3	1	5	2.65
August	1	0	2	0	3	1.58
September	1	0	1	0	2	1.05
October	5	0	4	1	10	5.30
November	7	0	1	1	9	4.76
December	33	0	2	2	37	19.60
Total	149	8	25	7	189	100.00

* Data for 1955 are for January–March, inclusive.
† 82.6 per cent of all breaks occurred in the period Nov. 1–Mar. 31.

two breaks occurred in a single day; 5 of these 8 days were in 1955. Twice in January 1955 there was one break per day for 3 successive days.

The importance of stresses induced by temperature variations is further borne out by the large number of main breaks occurring in the 1954–55 cold season. Although the incidence of main breaks increased from one in 1940 to nineteen in 1954, these figures do not compare with the occurrence of 35 breaks for the 1954–55 cold season, when almost twice as many breaks occurred as had been experienced in any previous comparable period. This phenomenon may probably be explained by the fact that a colder water was furnished to the former town of Lake area during these months.

Although the town was consolidated with the city of Milwaukee on Apr. 7, 1954, it was Nov. 1 of that year before the Milwaukee water works furnished 100 per cent of all water used in the town from the Lake Michigan source of supply. The water formerly supplied from the town's three wells had a constant temperature of 52°F. Water delivered from the Lake Michigan source, however, had a temperature as low as 38°F. The additional temperature stresses induced by a colder water could be the cause for the increased number of breaks that were experienced in the 1954–55 cold season.

Summary

It is believed that the primary reasons for the numerous water main breaks in the distribution system of the former town of Lake is the existence of improper trench conditions for the thinner walled pipe that was used, plus temperature variations. Improper trench conditions were caused by faulty inspection which permitted poor construction methods to be used, such as intense competition between crews, improper preparation of the trench bottom, improper use of blocking, and improper backfilling.

Some Practical Aspects of Pipe Laying

Roy Ruggles

A paper presented on Mar. 20, 1956, at the Southeastern Section Meeting, Augusta, Ga., by Roy Ruggles, Chief Engr. of Constr., Atlanta Water Dept., Atlanta, Ga.

IN preparations to lay a water main, the first question that comes to mind is where to lay it. The established rule of the Atlanta Water Works is to install water mains in the north and west sidewalk areas. If the physical condition of the route prohibits this, however, the north and west portions of the street are used.

Field Survey

A field survey is made to determine property lines and correct length of main to be laid, and to obtain information on obstructions in the route of the proposed main. A field sketch is drawn on which trees, shrubbery, embankments, fills, bridges, railroads, and other such obstructions are noted. The high and low points are determined, as is the approximate location for hydrants. When these data are obtained, the other utility companies are visited and the locations of their underground structures are added on the sketch.

Working Drawing

After field work is finished, the sketch is turned over to the engineering department, where a working drawing is prepared. This drawing shows the size, class, and length of pipe, material required, and other pertinent information. If bridges are to be crossed, hangers are designed to support the pipe. Where it is necessary to lay the main under the bridge, the angles for bends are determined and brace blocks are designed.

When it is necessary to tunnel under railroad tracks, a drawing is made showing the size and location of proposed main, location of nearest mile post, and type of casing to be used. Several copies of this drawing are submitted to the railroad company for authorization to extend the main under their tracks.

Trench Preparation

In Atlanta, Ga., types of soil vary from blue swamp mud to hard shale and rock. The principal type is red clay, which is usually self supporting and requires no shoring at the average depth of a ditch sufficient to give 3½ ft of cover to the mains and wide enough to permit about 8 in. of clearance on either side of the pipe.

In preparing the trench for laying pipe, the bottom is leveled and a layer of soft earth about 2 in. thick is left in the bottom to provide a uniform bed for the pipe. Bell holes are cut in the usual manner.

When it becomes necessary to lay a main through a cinder fill, cinders are removed and replaced with a backfill of fresh earth so that no cinders will come in contact with the pipe.

If a main is laid through rock, a clearance of 8 in. between the rock and all points on pipe, fittings, and

valves is required. Earth is then placed in the bottom of the trench as a cushion.

Bracing

Hydrants are strapped to the tees, except where the earth is exceptionally firm, when the hydrant and tee are braced firmly with rock. Loose crushed rock is placed around the shoe of the hydrant for drainage purposes. All bends and portions of pipe that are subject to movement are thoroughly braced with rock or concrete blocking designed to withstand the calculated thrust. The size of the blocking also depends on the type of soil through which the main is being laid.

Where the pipe extends through bridge abutments or over a sewer, pipe joints are made close to the masonry or concrete to allow slight movement of the pipe if the earth settles. In bridge abutments, an opening at least 2 in. larger than the outside diameter of the pipe is provided and a mixture of asphalt and cotton seed hulls is packed in the opening around the pipe to serve as a cushion.

Preparing Pipe

The Atlanta water works has developed a template which can be used on 12-in. pipe or larger as a guide for painting a stripe around half the circumference of the pipe on the spigot end. This stripe marks the exact depth that the spigot end should be inserted into the bell end of the pipe. Use of the template is illustrated in Fig. 1 and 2. It has proved to be a great help in laying pipe, because the actual distance which the spigot extends in the bell can be seen by observing the stripe. If this method is used, it is not necessary for a man to crawl in the larger pipe to check the joint. Work can thus proceed much more rapidly, as well as with greater accuracy.

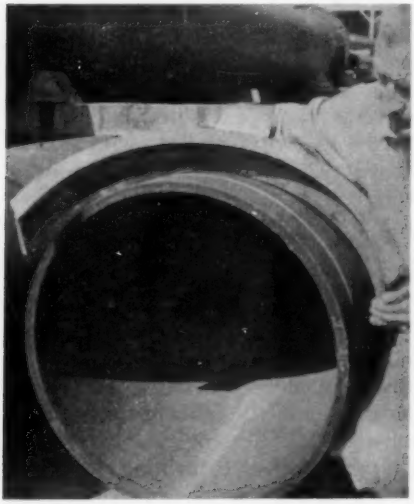


Fig. 1. Use of Pipe Template



Fig. 2. Painting Spigot End

There is a tendency for a main laid on an incline to "creep." To determine if such creeping is taking place, another tool has been developed. It is a scribe about 2 ft long, having two pointed ends turned at right angles to the main bar. A center punch mark is made on the bell of the pipe and another on the barrel of the next pipe so that the two points of the scribe will fit in each mark. Any movement of the pipe can be readily detected by comparing the scribe points with the punch marks.

Cement-lined cast-iron pipe which has been seal coated is used at Atlanta. The pipe is delivered by both railroad and trucks, and special care is exercised in loading and unloading the pipe to prevent shock which may later cause breakage.

When installing pipe in the trench, a length of pipe is lifted with a crane and lowered to within a short distance of the bottom of the trench, but it is not allowed to touch the earth. While the pipe is in this position, a circular brush, having a handle of 1-in. pipe, is passed through the pipe and back again to clean out any foreign matter that may be adhering to the inside walls. This brush, which is the same diameter as the inside of the pipe, is approximately 4 in. thick. One-half of the brush is made of stiff fiber bristles, and the other half is of finer bristles. The stiff bristles loosen any material that may be adhering to the pipe walls and the fine bristles clean off the dust. Where mechanical-joint pipe is used, the spigot end is washed with soapy water while the pipe is suspended; then the follower ring and rubber gasket are placed over the end, and the pipe is inserted in the bell. The gasket is slipped in place and the ring is bolted to the bell in the usual manner. By thoroughly brushing the interior of pipe before laying, washing the spigot and bell ends, and keeping the end capped to prevent anything from entering the pipe when pipe laying is not in progress, the Atlanta water works has found that, in general, it is only necessary to flush a new main thoroughly to obtain a bacteria-free sample before placing the main in service.

When the installation is completed the main is thoroughly flushed and a sample of the water is tested for purity by the water works laboratory. If the results are negative, the main is placed in service.

Records

As soon as the work is completed, a field book record is made of the installation, indicating the length, depth, and class of pipe, and the location of the main. Also the location and make of hydrants and valves are recorded. Other data, including bends, special bracing, supports, and all information that will be of help in future work, are incorporated in the notes. When field notes are completed the data are transferred to permanent records on legal-sized cards. The drawing made on these cards shows several street intersections. The streets are drawn to a scale of approximately 100 ft to the inch, but the width is purposely exaggerated to show locations more clearly. If necessary, they can also be laid together to form a map. These cards are numbered consecutively and each intersection is cross indexed on a telephone type of index file for quick reference. Photostats are also made of the cards for use in the field.

Economic and Human Values of Safety

Arthur J. Webb

A paper presented on Oct. 26, 1955, at the California Section Meeting in Sacramento, Calif., by Arthur J. Webb, Safety Coordinator, East Bay Munic. Utility Dist., Oakland, Calif.

DURING the past two or three years, the water works industry in the US has rapidly awakened to its responsibilities in the field of safety. The Bureau of Labor Statistics has made a detailed study on injuries in the water industry, and the AWWA has produced a complete safety manual. It is evident, therefore, that safety is assuming its rightful role in water works plan of operations.

What is safety? Or rather, what is it not? Safety is not a program of give-aways, prizes, and awards. Safety is not the achievement of a no-accident record. Safety is not wearing hard hats. But it is the philosophy that one is his brother's keeper; it is a personal project, especially among the personnel who run the company. Any company hiring a man is responsible for his welfare when he is on the job. There are also legal and moral factors that govern this philosophy. State law requires the maintenance of a safe place in which to work. Failure of this maintenance can lead to excessive liabilities. Safety is also a moral responsibility. Injuries and deaths caused by carelessness and lack of safety precautions are unforgivable.

Insurance Rates

Business operations face grave financial risk where injuries to personnel are concerned. The state law rightfully requires that a safe place for employees to work. This provision has resulted in many huge claims and lawsuits. Claims of $75,000 and over are not unusual today. In Alameda County, a company is being sued for over $250,000 for one injury. These suits are not covered by insurance for compensation, medical, and hospital expenses. How many such cases could any company absorb without jeopardizing its very existence?

All companies must carry disability compensation insurance or satisfy the state that they can insure themselves. There are fewer self-insured companies in the state than insurance companies. The state sets basic rates for insurance costs of various occupations. Insurance charges are based on these rates. The water works industry is a large enough insurance unit in California to receive a rating separate from other industries, and will therefore have lower or higher basic rates depending on the number of accidents and the number of people who are disabled in the industry. Reducing accidents means reducing direct insurance costs.

Companies can save money individually by having good accident experiences. Last year the East Bay Municipal Utility District paid $75,000 in compensation insurance premiums. With regard to accidents, 1955 was a good year with an experience of 6.5 lost-time accidents per million manhours. As a result, the company received a refund of over $45,500 on the premium, or 60 per cent of the

original. In 1954, the company paid $65,180 in compensation insurance and received a dividend of almost $45,000. These refunds reflected reduction in lost-time accidents per million man-hours from twenty to three. The present average is about four accidents; not as low as it could be. By teaming up to reduce accidents, every water works in the state will benefit from the reduction in basic insurance rates.

Responsibility

Who are the important men in a company? The managers, the salesmen, the servicemen? How far would they be able to operate without pipelayers, ditchdiggers, and the men who run big rigs or keep books. The fact that they are on payrolls should mean that they are very important people who must be given, among other things, safe places to work.

Water works management too often feels that, as insurance companies are bound to pay for all injuries, there is no need to hire a safety man or institute a safety program. Management people tend to emphasize dams and treatment rather than accident prevention. Many companies admit knowing little about safety programs.

Definition and Comparison

The Bureau of Labor Statistics report shows that in the nation as a whole, the water works industry has a frequency of 22 lost-time accidents per million man-hours. This means that, in a year, out of every 500 employees, 22 were injured so badly that they could not return to work the next day. In California, water works have the same frequency experience.

A lost-time accident is one in which injury prohibits work the next day. If 500 employees work one year, a million man-hours are clocked. If 22 of those employees have a lost-time accident, the frequency will be 22. The Bureau of Labor Statistics reports a water company with a frequency of 500. This means that there was an average of one lost-time accident in the year of 1953 for every employee in the company. Can a water works company afford that type of operation?

The gas industry has a frequency of 10.51. The communications industry has a frequency of 1.3. Steel mills and automobile manufacturers have frequency rates of 3.85 and 2.68 respectively. The national average for all industries in 1955 was 7.22 lost-time, accidents per million man-hours, or approximately one third of the water works frequency. A company having 50 employees can afford only two lost-time accidents in a year to have a frequency of 20. One lost-time accident would give a frequency of 10.

Previous Measures

Many people are working to decrease the high water works accident frequency. In California, the transportation, communications, and utilities committee for the Governor's industrial safety conference is setting up a system of awards for good performance. The committee also plans to distribute a brochure on the basic principles of a safety program.

The AWWA in New York has taken two important measures. The first is the production of a complete safety manual for the water works industry (*1*). A complete text of this manual was published in the JOURNAL for July–December 1955. The other measure is a system of awards, now in the process of development.

Louis J. Alexander, chairman of the California Section of AWWA, established a task force to study safety in

the water works industry. Acting as chairman, the author called on A. C. Rener, District Operations Engineer, Los Angeles Department of Water and Power, and Norman Andrews, Assistant General Manager of the San Jose Water Works, to study the problems. Other members of this committee represented construction and maintenance, and business affairs and community relations. The author represented the safety field. After an all-day session on this subject, the committee recommended that the California Section of the AWWA do the following things:

1. Promote safety in each water works in the state.
2. Furnish safety promotional material for water utilities.
3. Furnish program outlines for the use of AWWA manuals and other educational media.
4. Draw up a basic design for a safety program in any water works industry.
5. Publicize safety in the industry.
6. Have the safety committee promote a safety contest nationally within AWWA.

The committee suggests that the top management of all participating companies of the California Section be contacted and asked to participate in the program outlined above. This program would best be accomplished by establishing a permanent safety committee within the present structure of a section. When a water works company, no matter how large or small, sets up its own safety program, the following points should be considered:

1. Management must be personally concerned in the reduction of accidents.
2. Top management must state its personal position and lead by example.
3. AWWA can help by collecting, analyzing and distributing data.
4. Accident analysis should be carried out before treating the symptoms. Accident review boards are of great help in the procedure.
5. Results of the study should be made known to all in the company.
6. Safety measures should be outlined to personnel. Most employees will want to follow set procedure.
7. Accident prevention should be stimulated with items like gadgets, posters, and contests.
8. Property should be inspected regularly. A worker committee may do this.
9. Safety councils and insurance companies should be asked to help. The author works regularly in full cooperation with the East Bay chapter of the National Safety Council.
10. It is important that the responsibility for a program be assigned to one individual who will develop it.

Safety precautions have paid off in good employee relations and in reduced accident frequency. It would do well to remember, however, that a good record is a reward and not an objective. The objective is to have safe working conditions and good attitudes toward accident prevention. Every employer should remember that an individual important enough to be asked to do a job is important enough to protect. Promotion of safety measures and implementation of these are urgently needed. They will benefit everyone.

Reference

1. *Safety Practice for Water Utilities.* AWWA Manual M3. Am. Wtr. Wks Assn., New York, N.Y. (1955).

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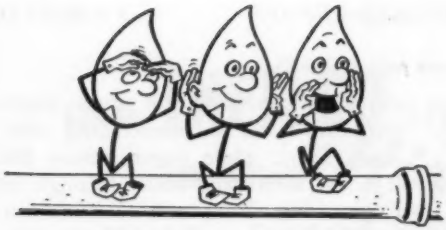
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Percolation and Runoff

'All the Water You Need'—our October exhortation—or even half that much would, at the time of this writing, be worth at least 102 electoral votes to the presidential candidate who could convince voters of his ability to deliver, for, from Texas and Oklahoma right up into the Dakotas, at least eleven states are desperately droughtbound, and weathermen are promising no real relief until 1959. By that time our suggestion of importing polar ice into Texas may already have been adopted or someone may well have discovered a way to convert oil into water. What with Dallas already drinking water marketed in milk containers at 50 cents a gallon, compared to the 7 cents a gallon price of crude oil, the incentive for some latter-day alchemist ought to be more than sufficient.

That the Sahara, which author Philip Wylie, in a recent *American Weekly* article, threatened as "America's heritage, unless . . . ," may be coming faster than even he feared is nowhere more evident than in Texas. There, 185 of the state's 254 counties are already classed by the federal government as drought-disaster areas and the estimated $750,000,000 loss to farmers and ranchers grows with every rainless day. Bad enough of itself this year, when Dallas cooked up a record 38 days with temperatures from 100° to 109°F, but coming at the end of 7 or 8 years of inadequate rainfall, the drydom has been what one newsman called "monumental" in its impact.

Even so, there aren't many Texans who would hesitate to say that Texas can get all the water it needs—with a little doing. And the doing is certainly not being discouraged by the current crisis. Unfortunately, though, more-water doings take time, and the immediate is pretty uncomfortable. Yet even on that score, some Texans are proving ingeniously self-sufficient. At Stamford, for instance, Mayor W. B. Robinson and his city council met one day and proclaimed the following Tuesday a "rainy day." And, of course, it rained—only 0.02 in. to be sure, but next time the proclamation will be more strongly worded. Then, at Austin, the State Water Board received instructions to put pressure on Washington to stop the Navy hurricane hunters from their diversionary tactics, to give Texas a taste of some of those deluges that flooded New England last year. And, on a more personal plane, at Richardson, Jess Tripp called out the local fire department to put out a fire in his well. It was burning sure enough—fumes from a broken butane line having been ignited by a spark from the water pump and burned $150 worth of damage into the side of the Tripp house—but with water worth 50 cents a gallon, Jess ended up with a good bit more than $150

(Continued on page 36 P&R)

(*Continued from page 35 P&R*)

worth in his well before the blaze was subdued. There's more than one way —that's for sure!

As for Oklahoma, they have their own separate and distinct ways, the best of which was good enough to rate a couple of pages in *Life* last May. Concentrated faith was the secret weapon which residents of Hobart, Okla., successfully brought to bear on the elements, when, under the leadership of local druggist Jim Bledsoe, the town donned its raincoats and rubbers to prove that they really had faith in the effectiveness of their preacher's prayers for rain. It took a sunny 101°F day under an umbrella, but the technique apparently worked, for where plain prayers had been unsuccessful for over 2 years, the implemented ones paid off in less than 24 hr, and the rains continued for a week, leaving from 5 to 14 in. over the whole area.

Whether by proclamation or politics, fire or faith, though, rain is still needed by a thirsty third of our states. And from time to time and place to place, people will have to depend upon such rather uncertain techniques to survive the dry cycles until they realize that for considerably less than 50 cents a gallon they can be provided "all the water they need, when and where they need it!"

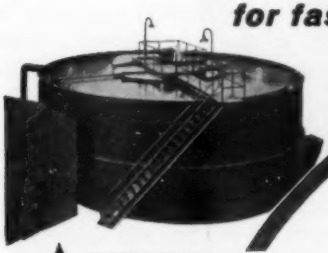
Not the shortage of water as much as the shortage of water works engineers is becoming our most serious problem these days, for the water problem is one of distribution whereas the engineer problem is one of creation. Why there should be a shortage of engineers at the prices being offered to new engineering graduates may be a little difficult to see when time isn't taken into account, but why there should be a shortage of water works engineers is all too immediately obvious. Thus, while organizations like EJC on a national scale, through its Engineering Manpower Commission, and the Engineers Club of Kansas City on a local scale, through $8,000 a year of scholarship grants in aid, try to create engineers, and while the Water and Sewage Works Manufacturers Association, through the Harry E. Jordan Scholarship Fund, and James B. Clow & Sons, Inc., through its three Clow Graduate Fellowships, try to make those engineers sanitary engineers, it behooves the water works field itself to get on the ball to make itself financially attractive. That, of course, gets back to economics, which gets back to public appreciation, which gets back to "What Price Water?"—for which, not to be repetitious, see above.

Paul A. Kuhn, first recipient of the Harry E. Jordan Scholarship Award, has taken a position with Stanley Engineering Co., Muscatine, Iowa, after completing his MS thesis, "Removal of Ammonium Nitrogen From Sewage Effluent," at the University of Wisconsin. Assigned to the sanitary design section of the firm's civil engineering department, his first job is the design of a water treatment plant for a northern Wisconsin paper mill. A graduate of the University of Illinois, Mr. Kuhn received the Scholarship Award in 1955. The scholarship is supported by an education aid fund established by the Water & Sewage Works Manufacturers Assn. Recipients are selected from a different region of the United States and Canada each year by a committee appointed by the President of AWWA. The 1957 awardee will be from northeastern United States or eastern Canada.

(*Continued on page 38 P&R*)

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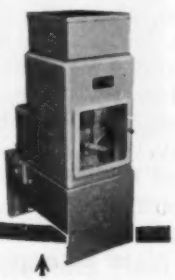
INFILCO INC.

General Offices, Tucson, Arizona

*The **one** company offering equipment for **all** types of water and waste treatment.*

FIELD OFFICES THROUGHOUT THE UNITED STATES AND IN FOREIGN COUNTRIES

5637-A



DRY FEEDERS

The E Feeder—the only feeder with linear setting for adjusting rate of feed throughout entire capacity range. Extrusion type imparts simultaneous rocking and reciprocal motion of feed pan; for either constant rate or automatic proportional feeding.

Request Bulletin 215-CC

FILTER CONTROLLERS AND GAUGES →

The C.-A.-P. SYSTEM® instruments afford maximum efficiency in pneumatic control of treatment plant operation, provide sensitive flow control, accurate measurement of loss of head and rates of flow.

Request Bulletin 1100-C



(*Continued from page 36 P&R*)

The masthead of the September 1956 issue of *Water & Sewage Works* reads: "Linn Harrison Enslow, Editor." It has read that way for 25 years—since October 1931, when Linn Enslow left his position as research engineer for the Chlorine Institute to edit what was then called *Water Works & Sewerage*. To his alert and energetic guidance and numerous innovations, much of the success of that magazine is attributed by its publisher, E. Scranton Gillette. That Linn En-



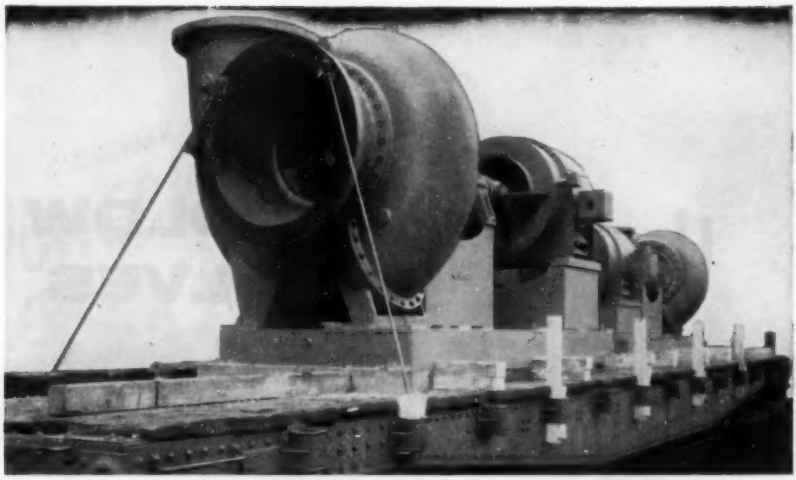
slow's contributions to the progress of the water industry are not limited to journalism alone is a fact needing no amplification for members of AWWA. A holder of the Diven Medal, the Goodell Prize, the Fuller Award, and Honorary Membership, he has found time during his busy career to serve AWWA as Director, Vice-President, and President, and has been a moving spirit on its committees. His silver anniversary as editor is a milestone in a life of distinguished achievement.

What the American Legion has, what the VFW has, what the Ancient and Accepted Scottish Rite Masons have, the Texas Water and Sewage Works Association now has, too—a ladies auxiliary, that is—perhaps a first step toward an American Water Wives Association. Organized Mar. 8, 1956, during the sessions of the water works short school at Texas A&M, the TWSWA noted as its purpose "the entertainment and social enjoyment of the membership." Under the leadership of President Mrs. Sidney L. Allison of Corpus Christi, Veep Mrs. Winfield S. Mahlie of Fort Worth, and Secretary-Treasurer-Editor Mrs. Leroy N. Rice of Harlingen, the organization has now grown to a membership of 63 and has added to its purposes education and philanthropy as well as fun. Already in print are the first two numbers of *The Pipette*, the group's quarterly newsletter, which is soliciting advertising with the idea of using the income for its philanthropic ends.

No bridge club this, the gals seem to want to get under the bridge and down in the water to find out what their husbands are doing and to be of some assistance. And who was it that said southern belles just stand by and wring their hands? Just wait for Dallas in 1958, when all of AWWA will be exposed to this auxiliaration.

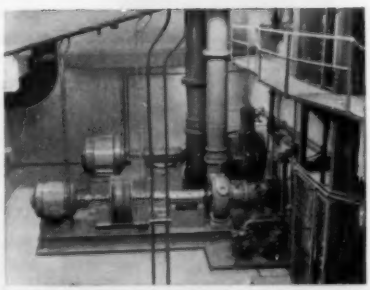
A chief utility accountant is being sought by the Philadelphia Water Dept. to head its accounting unit. Applicants should have a utility accounting background and be familiar with accounting procedures analysis and large-scale cost accounting. A college degree in accounting or equivalent, together with at least 7 years of experience (4 in a supervisory capacity), is required. Salary will be $8,900–$11,200. Resumes should be sent to W. J. Schwabe, Personnel Officer, Water Dept., 1120 City Hall Annex, Philadelphia, Pa.

(*Continued on page 42 P&R*)



THESE WHEELER-ECONOMY PUMPS HOLD CONSTANT LEVELS IN THE NEW TRICKLING FILTERS AT DALLAS' WHITE ROCK PLANT

Two of the Wheeler-Economy pumps installed in the White Rock Sewage Treatment Plant for Dallas, Texas are believed to be the largest ever operated through magnetic couplings. In order to maintain constant levels in the suction wells and grit channels, each of the two units driven through magnetic couplings are governed by an elaborate float level control. This helps the big Wheeler-Economy pumps to maintain level within predetermined 6" limitations. Total pumping capacity of the four Wheeler-Economy pumps installed at the White Rock Plant is 134 million gallons a day.



WHEELER-ECONOMY HORIZONTAL, MIXED FLOW RAW SEWAGE PUMPS AT INSTALLATION

Rely on Wheeler-Economy for help in complex pumping problems, dependable delivery and performance that lives up to promise.

Wheeler-Economy Pumps in Operation at Dallas' White Rock Plant

- 24" suction x 24" discharge variable speed pump driven through magnetic coupling by a 250 HP, 2300 volt horizontal electric motor. Capacity 20,000 gallons per minute at 40' total dynamic head.
- 24" x 20" variable speed pump, driven through magnetic coupling by 200 HP, 2300 volt motor. Capacity 13,000 GPM at 40' TDH.
- 42" x 36" constant speed pump, driven by 400 HP, 2300 volt motor. Capacity 40,000 GPM at 37' TDH.
- 24" x 20" constant speed pump, driven by 200 HP, 2300 volt motor. Capacity 20,000 GPM at 37' TDH.

WE525

WHEELER-ECONOMY PUMPS

C. H. WHEELER MANUFACTURING CO., ECONOMY PUMPS DIVISION
19TH AND LEHIGH, PHILADELPHIA 32, PA.

UP TO 72"

LUDLOW VALVES

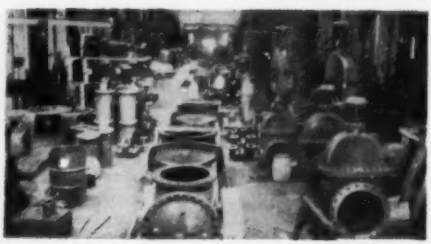


The water supply for thousands of people may depend upon a few large valves which must be reliable. Only a huge, specially equipped foundry, backed by giant tools, in a modern precision machine shop can supply this dependability. Ludlow has been the headquarters for large valves for nearly a Century.

LONG LIFE and DEPENDABILITY are built in. Ludlow Valves are fully bronze mounted. The two piece wedging mechanism is simple and rugged. The double disc parallel seat construction results in a wiping action that cleans the seats during the closing operation. The stems are special high tensile strength Ludlow manganese bronze with precision cut modified acme threads.

"NO POSSIBLE DIFFERENCE IN FIRST COST CAN OVERBALANCE THE PERPETUAL ECONOMY OF QUALITY."

17



Ask for Bulletin 547W



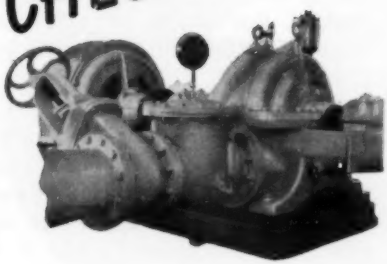
THE LUDLOW VALVE MFG. CO., INC. TROY, N.Y.

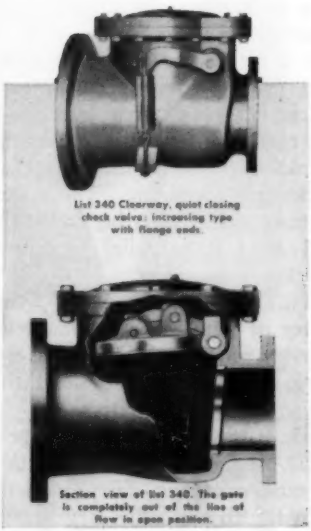
TRADE LUDLOW MARK

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES
CHECK VALVES • TAPPING SLEEVES • AIR RELEASE VALVES

CLEARWAY—QUIET CLOSING

CHECK VALVES





List 340 Clearway, quiet closing check valve: increasing type with flange ends.

Section view of list 340. The gate is completely out of the line of flow in open position.

Low cost insurance against severe slam on pump shut down is provided in the Rensselaer clearway, quiet closing, non-slam check valve.

In operation, the gate is normally completely out of the line of flow and head losses are extremely low, even at high velocities. The lever arm and adjustable spring force the gate toward its seat on pump shutdown and the gate seats firmly at the instant of zero velocity, without slamming.

The List 340 Spring Check Valve may be installed in either horizontal or vertical pipe lines and is made in sizes up to 30 inch and pressures of 200 lbs. with flange ends only. Dual levers and springs may be provided for extreme conditions. All parts are readily accessible through the large removable cover.

The increasing type illustrated bolts directly to the pump discharge flange, eliminates increasers and saves valuable space. For locations where slamming is not anticipated, the Rensselaer list 37 without lever and springs is recommended. For higher pressures, the List 39 operates on non-shock cold water, oil or gas up to 400 lbs. W.P. 22



Ask for Bulletin "E"

Rensselaer VALVE CO.

TROY, NEW YORK

DIVISION OF THE LUDLOW VALVE MANUFACTURING CO., INC.

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES
CHECK VALVES • TAPPING SLEEVES • AIR RELEASE VALVES

(Continued from page 38 P&R)

A waxed-paper distribution system for supplying water in emergencies is now under development by the Federal Civil Defense Administration with the help of the nation's dairies and their allied industries. The "pipeline" to be used is as unusual in shape as it is in material, being in the form of a noncontinuous parallelepiped—the shape of a milk carton, that is—and that it actually is! Thus, the distribution system involved would start at dairies near the area affected by the emergency with the substitution of drinking water for milk in the dairy packaging operation. The water-filled cartons would then be marked clearly and shipped to relief centers in the stricken area.

This quick means of supplying safe water in disaster areas was devised to provide relief to the people of Stroudsburg, Pa., during the flood that followed Hurricane Diane in August 1955. Its success there prompted FCDA officials to consult with representatives of the dairy industry and with health and relief organizations to develop a program to assist areas ravaged by any of the natural or man-made calamities. When such disasters strike, it will be the local civil defense director who will turn the valve on the supply of parallelepiped water by getting in touch with cooperating dairies. From that point on, the water will speed along on a waxed surface.

A. P. Black, research professor of chemistry, has been named head of the recently organized research group in sanitary chemistry at the University of Florida, Gainesville. Dr. Black's resignation as head of the university's chemistry department took effect last July.

Graduate engineers—civil, mechanical, chemical, and sanitary—are needed by the Louisiana Dept. of Health for training as public health engineers, at a starting salary of $395 (no experience required). There are also vacancies in various public health engineer grades. For details, write to: State Health Dept., Box 630, New Orleans 7, La.

The burrowing hose mystery is back again—this time at Parris Island, S.C., the Marines' basic training camp, which has been getting enough of a hosing lately without it. Still it was there, last July, that Mrs. Bernard Pekala, wife of a staff sergeant stationed on the base, used a garden hose to fill her child's wading pool and, having finished, threw the hose aside for a few minutes to get things ready for junior. When she turned around to retrieve the hose, it was making a worm-line into the sandy soil and three "husky" Marines plus the "entire" fire department couldn't prevent the hole from swallowing up a full 20 ft of it.

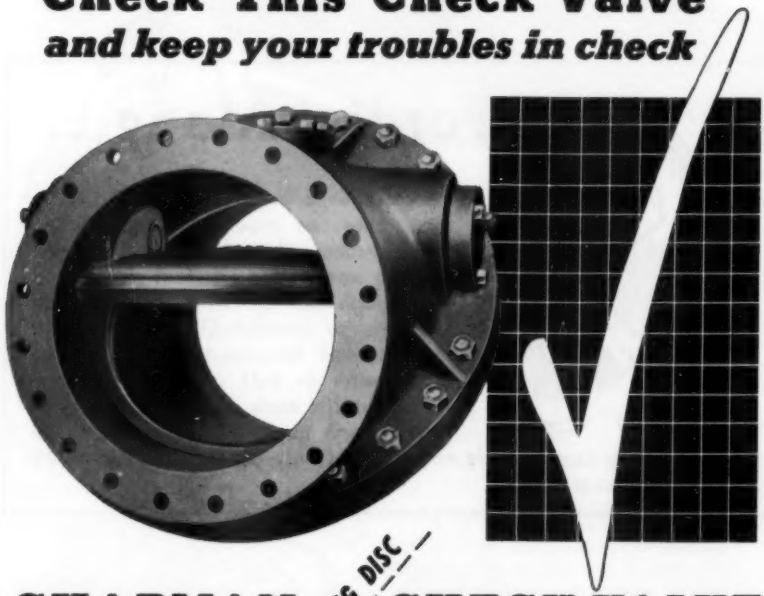
We don't doubt that this same sort of thing has happened before without the publicity that reporters—on the Island for other reasons—gave it. After all, the Marine Corps itself would hardly want to publicize the fact that three Marines—supposedly enough to handle a company of dogfaces—couldn't manage a length of garden hose. And certainly the individual Marines, aware of the obvious interpretation of their reporting such a fact, would never let it out.

Inasmuch as it is nothing new, we can only assume that the ground water used for supplying the base *really* seeks its own level!

(Continued on page 44 P&R)

Check This Check Valve

and keep your troubles in check



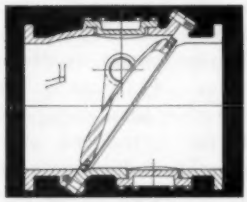
CHAPMAN TILTING DISC CHECK VALVE

Everything works in your favor.

With Chapman's Tilting Disc Check Valve there's no vibration, no fluttering, no noise. There's no slamming, with usual piping arrangements, no banging to cause damage to system or valve. There's no grinding, scraping or wearing to either the disc or seat.

All of this means less headaches to you . . . both physical and financial headaches. The smooth, sure, quiet action means less, much less, maintenance over the longest period under toughest operating conditions.

Chapman Tilting Disc Check Valves with money-saving advantages like these are available in iron and steel, with standard end to end, for handling fluids or gases under a wide range of pressures. They're listed and shown in our Catalog 30-A. Send for it and check the valves you need for replacement or new piping systems, now.



The Valve That Goes with the Flow

Here's the idea in back of it all. When the flow is on, "airfoil" disc is held firmly against stops in the body. When the flow drops, disc balances itself quietly on whatever flow there is. When the flow stops, disc drops quickly and tightly on special bevel seat. It's as simple as that. It's as sound as that. And valve men will be pleased when they see that enough room is given around disc to cut down flow resistance.

The CHAPMAN Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS



Fordin' Along...

Recent newspaper articles tell of a large city where the impounded supply is so nearly exhausted that it is necessary to bring in water from a distant river which has a high salt content. The brackish water is so unpalatable that quite a business has developed in the sale of fresh water in half gallon paper containers at 20¢ each. Few people realize that enough pure, safe water from the average public supply costs each citizen only about a nickel for all he can drink in a year.

(*Continued from page 42 P&R*)

The 'do-it-yourself' fad, which was born of necessity during the war, has already caught itself up to the atomic age. Fortunately for us—the done-to rather than doing—the atomic kits so far introduced are intended for combating radioactivity rather than creating it. Thus we can hope to survive at least one more Christmas before Junior gets his "Toddler's Fusion Set." In that time perhaps even we—who find ourself all thumbs and bruises with the things "a child can put together"—will have a chance to become proficient in the use of one of the new home drinking water decontamination kits.

Actually, of course, the decontaminators are "simple." We have that on the authority of the two sets of JOURNAL authors who invented them. The first, patented last July by A. H. Emmons and R. A. Lauderdale for the AEC, removes fission products by passing water through steel wool, clay, activated charcoal, and a mixed bed of anion- and cation-exchange resins. The second, developed by William J. Lacy and Don C. Lingsten at Oak Ridge, was described last September as also using ion-exchange resins which would remove up to 98 per cent of lethal radioactivity in 15 min.

Comforting as these discoveries may be, they do cause us pause in getting back to the war-necessity idea of "do-it-yourself." Still hoping for uncontamination rather than decontamination, we can at least be happy about the plug for the importance of water supply—better than if we did it ourself!

(*Continued on page 46 P&R*)



One Bright $ Sign in the Water Line

Most operations in the water processing line cost money . . . with little or no opportunity to make them pay for themselves.

One bright spot in the line is the water meter, which measures and determines the income. And when the meter is well set it can earn more by being well protected but still easily available for reading and changing.

Many water utilities are realizing thousands of dollars annually in labor savings and in increased revenues from well-set and well-maintained meters.

Perhaps you, too, can show bigger net profits this inexpensive way.

Send for
Ford Catalog No. 56.

THE FORD METER BOX COMPANY, INC.
Wabash, Indiana

FOR BETTER WATER SERVICES **FORD**

(Continued from page 44 P&R)

Fluorinews seems to be bulking larger and larger these days, particularly in the Detroit and New York areas, but what is news to those who write it and read it offers very little really new. One piece of late data we have been able to glean is the September 30 total of 1,400 communities adding fluorides to water supplies serving more than 30,000,000 people. Another is the fact that in 80 US cities serving fluoridated water to more than 15,000,000 people, there has not, according to the New York City Dept. of Health, been a single legal claim based on harmful effects of fluorides. Beyond this, the facts seem merely further confirmation of the 10-year findings at such places as Grand Rapids, Newburgh, Sheboygan, and Brantford. Not just the pros, but the antis, seem to be resting their cases on the same basic arguments wherever the controversy flares afresh, and reviews of those arguments have received the attention of such popular magazines as the *Saturday Evening Post* and *McCall's*, wherein the profluoridation conclusions of such reputable writers as J. C. Furnas and Robert L. Heilbroner are likely to carry considerable weight. On the anti side, one remarkable quote attributed to Charles E. Perkins, Washington, D.C., scientist and author, stands out: "I say this with all the earnestness and sincerity of a scientist who has spent nearly 20 years' research into the chemistry, biochemistry, physiology, and pathology of fluorine—any person who drinks artificially fluoridated water for a period of 1 year or more will never again be the same person, mentally or physically." Now, if he will only tell us what kind of water will keep us the same, we will at last have discovered the Fountain of Youth.

Meanwhile, our clippings continue much more fluoriviews than fluorinews.

Emil C. Jensen, chief, Div. of Eng. & Sanitation, Washington State Dept. of Health, has been elected vice-president of the Federation of Sewage & Industrial Wastes Assns. He succeeds John W. Cunningham, consulting engineer, Portland, Ore., who resigned for reasons of health.

Eugene L. Macdonald and Lawrence S. Waterbury have retired as general partners in the engineering firm of Parsons, Brinckerhoff, Hall & Macdonald, New York. Both men will continue as consultants, with Macdonald remaining as chairman of the board.

Dig those crazy Chinese—those "crazy" Chinese being the Red ones, and dig they do do—wells, that is, though not too well, it appears. At any rate, the headlines these days have been featuring the 144,500 useless wells that were sunk in one 6-month period this year in Shantung Province, mostly for irrigation purposes. Total area occupied by these wells—many of which were dug in places where river water was readily available for irrigation—was reported by the Peiping *Peoples' Daily* as 1,200 acres, with total manpower for digging and refilling them, 860,000 work days. Not wanting to be an apologist for these Chinese comrades, we certainly won't make any issue of the fact that these duds do represent less than 3 per cent of the total 5,000,000-well quota set for the province, but, water works or no, we can point out that they are headed in the right direction.

(Continued on page 48 P&R)



American Double-X Mechanical Joint Pipe, installed on cement piers parallel to Greensboro's original cast iron pipe water main.



This American Double-X Pipe line maintained water service in Greensboro, North Carolina, while the original cast iron pipe line was salvaged.

Double Line to Economy

American Cast Iron Pipe

American Double-X Mechanical Joint Pipe was selected when Greensboro, North Carolina, officials ordered a new water supply line.

Part of this new line, across a marshy area, was quickly and easily installed on concrete piers. These piers parallel the route of the original line, which was installed in 1924.

With the new line installed, maintaining service, the original line was dug up. It was then re-located on the same piers. Because it was cast iron, the pipe was in serviceable condition after more than 30 years in the ground. Both lines now supply water to Greensboro users.

These lines, the old and the new, demonstrate the dependable durability and proven economy of cast iron pipe. When you select pipe, specify American Cast Iron Pipe. You will get the longer service life that means greatest economy.

Corrosion-resistant, long-life cast iron pipe and fittings are manufactured by the American Cast Iron Pipe Company in 2″ through 48″ diameters. A wide variety of joints is available.

SALES OFFICES

New York • Chicago • Cleveland Denver • Dallas
Minneapolis • Houston • Orlando • Pittsburgh
Kansas City • San Francisco • Los Angeles

AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA

(Continued from page 46 P&R)

Singe Singe Prison is what they're calling it these days, for New York State's pen is just about dry. Cause of the water shortage at the "Big House," as well as at a number of nearby communities which have depended upon New York City's "old" Croton Aqueduct for their supply, has been the draining of "old" Croton Reservoir required by repairs of 1955 flood damages to Cornell Dam. The lowering of the reservoir waters has so roiled the remaining supply that the county health department has had to declare it unsafe for use. Among the towns affected, only Ossining has a filtration plant and has thus been able to continue drawing a supply from the aqueduct. North Tarrytown and Irvington, as well as communities which use water directly from the "old" Croton Reservoir, have been forced to look elsewhere for help. Meanwhile, Ossining has been keeping the 2,000 employees and inmates of the prison thirst-quenched and clean, but attempts to supply the fire hydrants of the prison have, for lack of adequate pressure, been unsuccessful, as has the attempt to fill the prison's 400,000-gal storage tanks. It is the resulting fire hazard that has been worrying prison officials and sent them in all directions to get usable water back into the aqueduct. Latest thought has been to skim off the good-quality water still on top of the Croton Reservoir and siphon it into the aqueduct. Pending some solution, Warden Wilfred Denno has imposed such strict conservation measures that those in solitary are expecting bread and wine any day now. That certainly would make it sing sing again.

(Continued on page 50 P&R)

✓Check these Features

Micrometer torque seating switch gives tight valve closure, and protects valve parts from damage.

Self contained unit—no gears, stem nut or bearings to buy.

Weatherproof, dust-tight, watertight and explosion-proof construction.

Hammerblow device . . . allows motor to reach full speed, before load is engaged.

Non-rotating handwheel built into the unit.

Automatic declutching.

Motor is disengaged during handwheel operation.

Can always be declutched for handwheel operation regardless of weather or electrical conditions.

High torque motors.

Simple valve yoke.

May be mounted in any position.

Three to four times faster handwheel operation.

Actuation may be by any available power source such as electricity, air, oil, gas, water or steam. LimiTorque is readily adapted for microwave control.

LimiTorque is designed for plug, butterfly, gate and globe valves up to 96" diameter . . . Entire Unit and nut can be lifted off valve yoke, by removing flange bolts.



A type SMA LimiTorque operating a 30" gate valve.

LimiTorque®

See the newest developments in Mechanical Power Transmission at our Booth #80 — 22nd National Power Show, New Coliseum, New York City, November 26-30.

PHILADELPHIA GEAR WORKS, INC.
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS
Limitorque Corporation • Philadelphia

Discover How
LONG-LIFE ACCURACY
Produces
MAXIMUM
LONG-LIFE REVENUE

City after city is joining the swing to CALMET for one basic reason . . . MAXIMUM REVENUE with MINIMUM UPKEEP, year after year.

Why don't you standardize on CALMET?



CALMET

"THE METER YOU CAN COUNT ON"

Manufactured by

Well Machinery & Supply Co., Inc.

Fort Worth, Texas

(Continued from page 48 P&R)

Any old Journals today? Occasionally AWWA receives communications from worthy organizations requesting donations of back numbers of the JOURNAL. If you will let us know which years' issues you are willing to donate, we will be glad to put you in touch with organizations desiring them, or to keep the information on file pending future requests. Write to Journal Donations, American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Crushed graphite ore is being offered as a filter medium for water plants by Graphilter Corp., Llano, Tex. It is said to be a superior medium because of its porosity, long bed life, and ease of backwashing, among other advantages. A uniformity coefficient of less than 1.8 is claimed for "Graphilter," which is made in five sizes and is obtainable in bulk or in 1-cu ft bags.

John S. Telfair Jr. has resigned as chief engineer of the Central & Southern Florida Flood Control Dist. to join the consulting firm of M. H. Connell & Assocs., Miami, Fla. Mr. Telfair, who had held the post since 1954, is expected to continue indefinitely as part-time consultant to the FCD governing board.

F. Homer Bell, field export manager of Philadelphia Quartz Co., Atlanta, Ga., died Aug. 30, 1956, after a prolonged illness. He had been an AWWA member since 1944.

Harry C. Boardman, director of research for Chicago Bridge & Iron Co., Chicago, died Aug. 6, 1956, at the age of 69. Born in Plainfield, Ill., in 1887, he received a degree in civil engineering from the University of Illinois in 1910. He joined Chicago Bridge & Iron in that year and remained with the company until his death, except for the period 1910–26, during which he served in World War I and taught at his alma mater.

Mr. Boardman was active in many professional organizations, including ASME, AWS (past president), ASCE, ASTM, American Petroleum Institute, Western Society of Engineers, and American Assn. for Advancement of Science. He had been an AWS representative on the Joint Committee on Steel Standpipes and Elevated Tanks.

(Continued on page 52 P&R)



BELL JOINT LEAK CLAMPS
GASKET SEALER COMPOUND
C-I-60 CAST IRON BOLTS

Carson glands and bolts made of corrosion-resistant C-I-60 cast iron—last as long as cast iron pipe. Glands accommodate variations in pipe dimensions, insure uniform compression of rubber gasket.

Write for information

H. Y. CARSON COMPANY
1221 Pinson St. Birmingham, Ala.

USE NORTHERN GRAVEL
for
RAPID SAND FILTER

FILTER SAND SPECIFICATIONS are carefully laid out. The Effective Sizes and Uniformity Coefficients used by Consulting Engineers and also recommended by the American Water Works Association are the result of long years of research and experience.

The Northern Gravel Company is equipped to give you prompt shipment whether it be one bag or many carloads, exact to specification. Filter sand can be furnished with any effective size between .35 MM and 1.20 MM.

CHEMICAL QUALITY of the filter sand is also important. It must be hard, not smooth and free of soluble particles. This requires perfect washing, and grading facilities. We have every modern device for washing, drying, screening and testing.

FILTER GRAVEL supporting the Filter Sand Bed must be, in turn, properly graded to sizes calculated to support the Filter Sand, and be relatively hard, round and resistant to solution.

The new Northeast Station in the City of Detroit, which is scheduled for completion in 1956, is one of the major projects included in the water department's expansion program. The Northern Gravel Company furnished 120 carloads of filtering materials for the 48 rapid sand filters incorporated in this plant.

Northern Gravel has no equal in facilities and our reserves of both sand and gravel are inexhaustible. Northern Gravel Company has been in business over 40 years. We guarantee uniformity of products and our records enable us to duplicate your requirements on short notice. Our location is central and we have commodity rates in every direction.

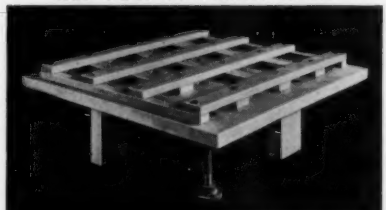
NORTHERN GRAVEL COMPANY

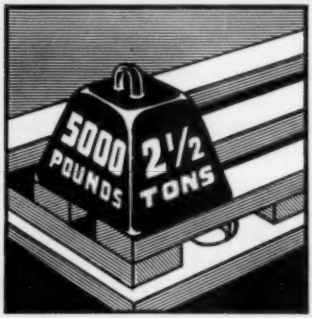
Muscatine, Iowa

P.O. Box 307 **Phone: Amherst 3-2711**

TRANSITE FILTER BOTTOMS

Cut Your Filtration Costs





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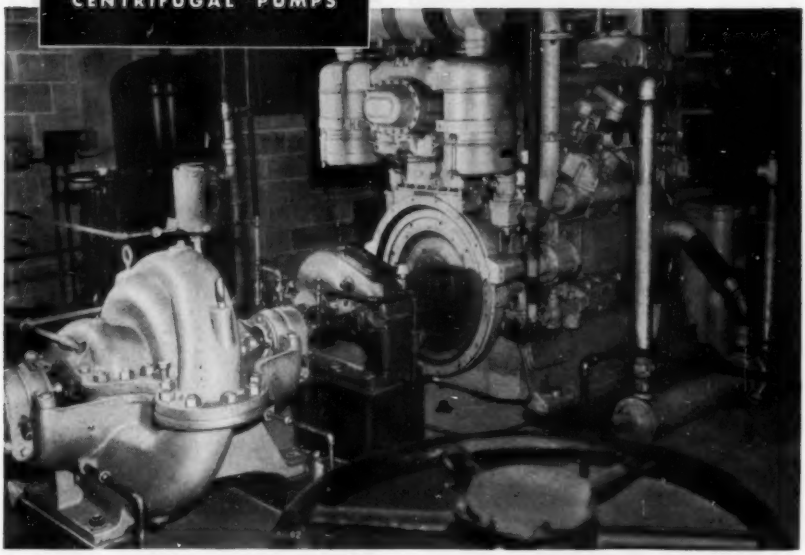
Frank M. Brooks, president and general manager of Brooks Products, Inc., Pasadena, Calif., died Oct. 5, 1956, at the age of 64. He was noted for his leadership in the affairs of his adopted city, Pasadena, to which he came from Santa Barbara, Calif., where he was born in 1892. Himself an active member of AWWA, Mr. Brooks' firm has held Associate Membership in the organization since 1920.

Walter S. Byrne, former general manager of the Omaha, Neb., Metropolitan Utilities Dist., died Oct. 5, 1956, at Seattle, Wash. He was 67 years old. A native of Baltimore, where he began his career in public utilities, Mr. Byrne came to Omaha Electric Light & Power Co. in 1908 and was later associated with Nebraska Power Co. He became general manager of the Metropolitan Utilities Dist. in 1939, serving in that capacity until 1954. The following year he assumed the presidency of Seattle Gas Co., retaining that post when the firm merged with another to become the Washington Natural Gas Co. He joined AWWA in 1939.

Pierre M. Hulsart Sr., retired division engineer of the New York City Board of Water Supply, died Sep. 18, 1956, at Syracuse, N.Y. He was 71. Born at Seabright, N.J., he was graduated from New York University in 1906. He began his career with the Board of Water Supply as a rodman, later becoming assistant engineer and, in 1949, division engineer. He retired in 1954, after 48 years of service with the board. Mr. Hulsart played a leading role in the development and construction of New York's Catskill Aqueduct.

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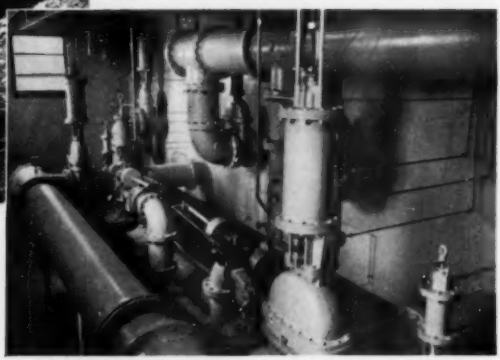
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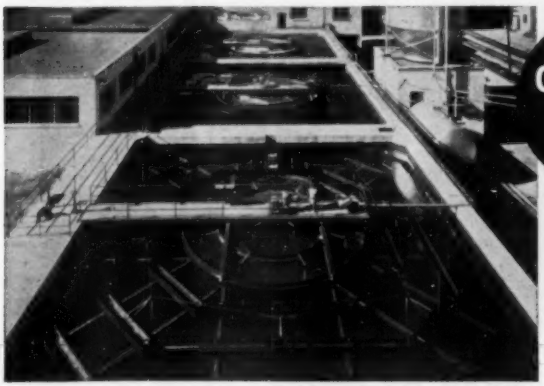
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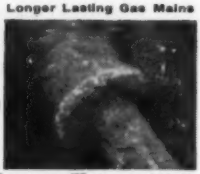
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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CORROSION

An Anomaly in Pipeline Corrosion Diagnosis. L. P. SUDRABIN. Corrosion, **12**:99 ('56). In midwestern refinery, complete penetration of 400-ft long 4-in. hot-water (170°F) line occurred within 2 yr in several sand-backfilled areas. Attack was not so evident on pipes in areas backfilled with loam-cinders. Apparently, porosity of sand allowed alternate immersion and exposure to air on the hot pipe surface, resulting in rust scale (Fe_3O_4) formation. This highly cathodic Fe_3O_4 scale, loosely attached to underlying bare metal, supports intense local-action corrosion cell. Loam cinder backfill, being less porous, tends to maint. more uniform vapor environment around heated pipe and thus retards formation of highly cathodic magnetic oxide scale.—*CA*

Effect of Ammonia Compounds on the Production Efficiency and Corrosion of Heat-Plant Equipment. D. S. SHEVTSOV. Teploenergetika (U.S.S.R.), **2**:48 ('55). Production tests were undertaken to det. possibility of employing NH_3 water (**I**) to feed steam boilers used in sugar industry. Modern 2-drum boilers were used with steam pressure of 25–32 and 39 atm. Temp. of steam was 375–450°. Boilers were fed by mixt. of 60–70% of products of primary condensation and 30–40% of product of secondary condensation—i.e. of so-called **I**. Expts. proved that **I**, in spite of tendency to form stable foam, can be successfully employed. Addn. of **I** also decreases salt content of steam. Steel boilers are practically protected from corrosion when **I** is used, which does not need to be deaerated when concn. of NH_3 is as high as 100 mg/kg. Bronze tubing of pumps is not attacked since it is not in contact with air, but bronze armatures of deaerators are rapidly corroded. Overall functioning of boilers is improved. —*CA*

Evaluation of the Chemical Corrosion Behavior of Cold and Hot Water. H. STEINRATH. Gas- u. Wasserfach (Ger.), **97**:140 ('56). Deposition of effective carbonate protective layer requires carbonate hardness of at least 3° (German, 1° = 10 g CaO/cu m water). However, hardness prior to heating should not exceed 10° or disturbing scale deposition will occur. $Ca(HCO_3)_2$ content must be low. Cl ion contents over 30 mg per l can affect protective layer. Content of nitrate and nitrite ions is generally unimportant, except for alloys contg. Zn. Content of NH_4 compds. over 20 mg NH_4/l causes corrosion of usual metals. NH_3 protects Fe but destroys Cu-contg. alloys. Phosphates and silicates limit corrosion. Fe plus Mn contents over 0.2 mg/l are harmful to Cu and Cu alloys. O is necessary for formation of protective coatings but causes corrosion with waters which do not form protective coatings. For formation of protective coatings, water temp. should not exceed 65° and max. temp. of heating surface should not exceed 90°.—*CA*

Reduction of Iron and Copper Corrosion in Steam and Water Cycle With Amines. S. M. SPERRY. Combustion, **27**:65 ('55). Ammonium compds., used in generating stations to prevent iron oxide deposition in boilers, was found unable to protect turbines from corrosion. NH_3 was largely lost in steam, resulting in lowered condensate pH and serious corrosion of condensate pumps. Cyclohexylamine and morpholine (**I**) were tested for suitability as NH_3 replacements. **I** was detd. to be more effective because of its stability at high temps. and pressures and its even distr. throughout steam and water cycle. Steam, condensate, and feedwater are maintained at pH of 8.8–9.0 with **I** residual of 3–4 ppm. By anals. of condensate, feedwater, boiler water, and steam, effectiveness of **I** treatment is compared with pH control by (1) recirculation of boiler salines, (2)

(*Continued on page 68 P&R*)



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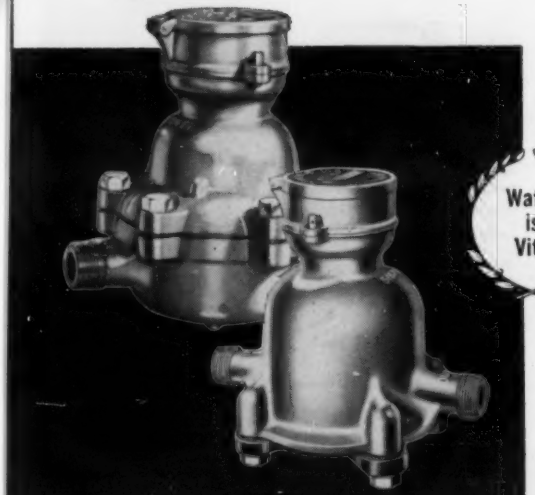
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(Continued from page 64 P&R)

NH_3, and (3) with no treatment, at 4 different generating stations. Properties of I and method for its detn. are described.—*CA*

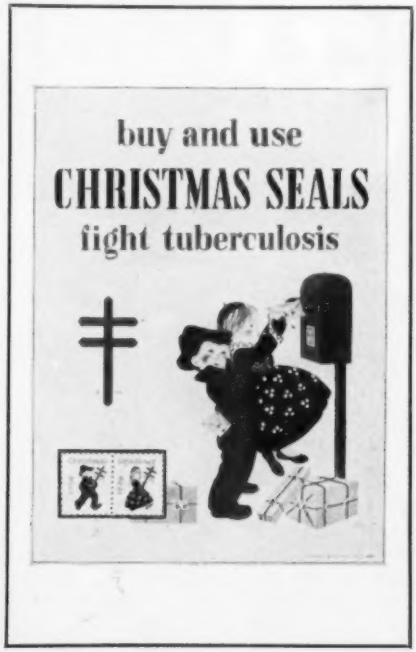
Water Main Cleaning and Lining. J. A. Frank & A. G. Perkins. Wtr. Sew. Wks., 102:150 ('55). Increased demand for piped water supplies and increase in per capita consumption of water call for max. capac. of pipelines. Loss of coefficient in water pipes can be recovered by cleaning, the 2 main methods being drag method for 4-in. and 6-in. pipes, and pressure method for 8-in. and larger pipes. Both methods are described in detail, together with use of pipe-cutting machinery and means of disposal of flushed-out waste water. Benefits obtained by cleaning are only temporary, and examples are given of retuberculation of cleaned pipes and other deteriorations. This can be overcome by utilizing modern methods of cement lining of pipes in position. Centriline process for centrifugally applying cement to interior of water mains is described. For pipes of 24-in. diam. and over, lining machine usually carries operator; for pipes of 24–16-in. diam., the machine is remote controlled. Thickness of lining applied varies with size of pipe, and is usually $\frac{3}{16}$–$\frac{3}{8}$ in. thick. Special fittings in pipe are shielded prior to lining. Tate lining process for pipes of 4–14-in. diam. is also described. Examples are given of successful use of both processes.—*CA*

BOILERS AND FEEDWATER

Selection of a Rational Scheme of Water Treatment for Drum Boilers Having High and Very High Ratings. M. S. Shkrob & I. M. Sokolov. Teploenergetika (U.S.S.R.), 2:38 ('55). 7 different possible water treatment methods are considered for 5 different types of available natural waters at several values of condensate return and drum blowdown for number of high-rating boilers. These combinations are compared graphically and in tables as to

(Continued on page 70 P&R)







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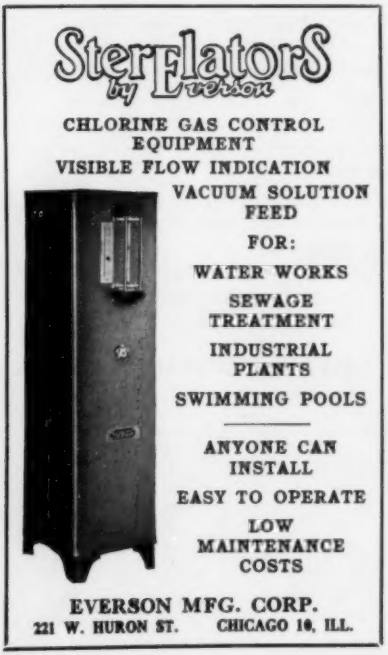
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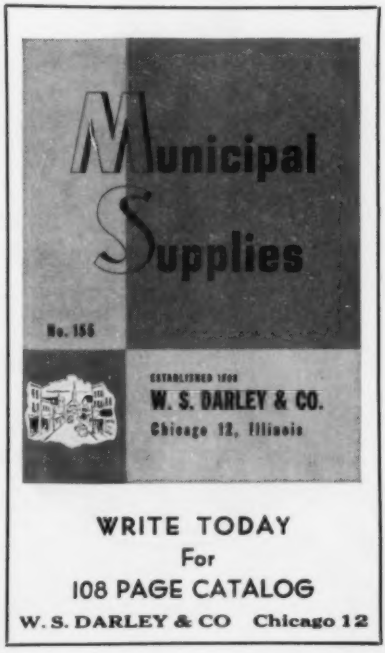
space requirements, steel consumption, and costs. Information aids in selection of optimum method for certain specific cases.—*CA*

The Chemical Deaeration of Boiler Water —the Use of Hydrazine Compounds. J. LEICESTER. Trans. ASME, **78**:273 ('56). Although use of hydrazine hydrate or dihydrazine phosphate would appear to provide ideal chem. method for deaeration of boiler feedwater, these compds. do not always react quantitatively with DO. Hydrazine-O reaction in dil. systems, such as boiler feedwater, would appear to be surface reaction. Mechanism of this reaction is not yet fully established but there is some evidence to indicate that it may be heterogeneous. Hence, it appears impossible to predict that hydrazine will work satisfactorily in all types of boiler plants. In view of possible surface-reaction mechanism, some form of catalyst unit in feedwater supply may be necessary. Decompn. of excess hydrazine to NH_3 in boiler water is related to completeness of hydrazine-O reaction and deg. of reaction occurring at oxide surfaces in system. Provided that residual hydrazine content of boiler does not rise above 0.2 ppm, it is unlikely that the NH_3 content of steam will be greater than 0.3–0.5 ppm. Danger of nonferrous-metal corrosion in presence of excess of NH_3 will make it necessary to use accurate metering equipment for hydrazine feed. New powd. hydrazine salt of dinaphthylmethanedisulfonic acid contg. 11–15% hydrazine offers promise. This material is also very active dispersing agent and assists in fluidizing solids in boiler; it is alk. in water soln.—*CA*

Controlling Iron and Copper Pickup With Neutralizing Amines. J. D. RISTROPH & E. A. YORKGITIS. Trans. ASME, **78**:287 ('56). With either morpholine or cyclohexylamine fed to maintain a condensate pH of 9.0 to 9.1, Fe and Cu concns. in No. 3 unit of Chesterfield Station are kept at very low values—less than 0.01 ppm throughout

(*Continued on page 72 P&R*)

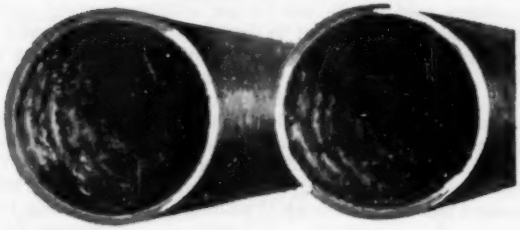




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*From a paper written by Mr. John B. Dean, Division Engineer, Water Div., St. Louis, Mo.

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(*Continued from page 70 P&R*)

steam-condensate-feedwater cycle. Attainment of these desirably low levels may be due in part to rigid control over other factors influencing pickup of metals in steam-feedwater cycle, especially O contamination. Good sampling facilities and analytical procedures are essential in obtaining reliable data. Of particular importance are continuous flow of samples, solubilization of Fe and Cu in sample, and use of sensitive indicators such as bathophenanthroline and neocuproine in detns. of these metallic contaminants. Sampling methods are described and especially necessity of soaking glassware in HCl soln. (1:4) for several hr followed by further cleaning with phosphate detergent and extn. with reagents used in analyses. Anal. procedures used for Fe and Cu are adaptations of methods employed by Smith, which are given in detail. Feed requirements for maint. of pH are approx. same in cycle under study for either morpholine or cyclohexylamine. Build-up of NH_3 in system because of breakdown of either amine is negligible. However, part of small amt. of NH_3 discarded with after-condenser drains represent possible breakdown of amines.—*CA*

Hydrazine as an Oxygen Scavenger—a Progress Report on Tests at Springdale Station. M. D. Baker & V. M. Marcy. Trans. ASME, **78**:299 ('56). N_2H_4 has been fed, on trial basis, to boiler operated at 1350 psi since Apr., 1954. N_2H_4 reacts only slowly with DO at ordinary temps.; this is also true with satd. steam at 345°F. In boiler at 1350 psi, excess N_2H_4 decomposes so rapidly that it is impossible to maint. more than few hundredths ppm in boiler water; under these conditions decompn. product is NH_3. Decompn. appears to be substantial in superheater with max. temp. of 930°F. Rate of decompn. in boiler at 115 psi is relatively low since it is possible to maint. reserve of at least several ppm in boiler water; at this pressure steam carried from 5 to 10% as much N_2H_4 as is present in boiler water; volatilization is greater at 1350 psi. N_2H_4 does not add to dissolved solids in boiler water. When N_2H_4 is used as O scavenger, pH of condensate is increased by NH_3 formed by its decompn. Metal pickup by condensate at pH not exceeding 9.2 while feeding N_2H_4 did not exceed 0.015 ppm Fe and 0.003 ppm Cu. N_2H_4 is currently several times as expensive as Na_2SO_3 for removing unit of O and about as expensive as K_2SO_3. Basic problem in use of N_2H_4 in high-pressure plant is detn. of amt. of N_2H_4 to add to feedwater to avoid waste. Anal. methods are given for N_2H_4, Fe, Cu, NH_3, DO, and pH, as used at Springdale Station.—*CA*

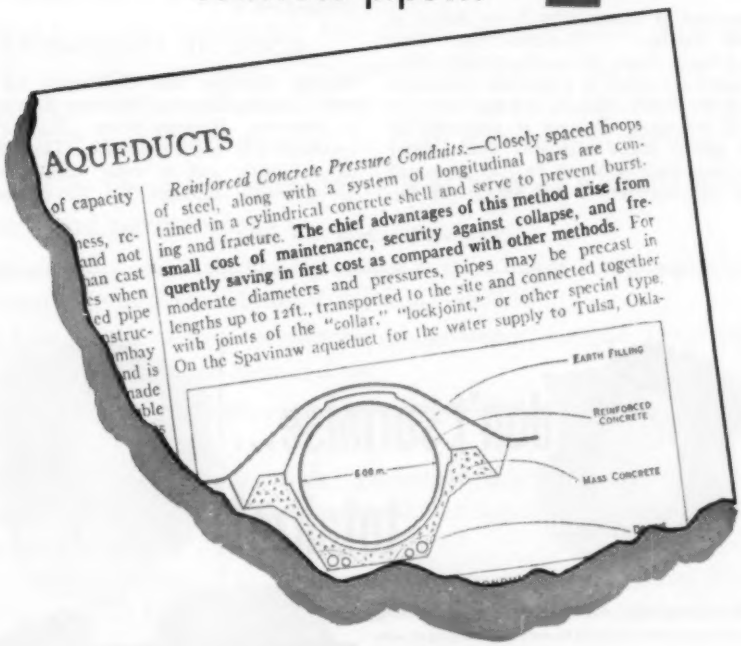
CHEMICAL FEEDING, CONDITIONING, AND SEDIMENTATION

Use of Pulverized Quicklime for Water Softening. D. W. Jones. Wtr. & Sew. Wks., **102**:503 ('55). Water-softening operation at North Miami plant originally involved application of hydrated lime to hard well water in carefully proportioned amts. in mixing tank wherein resultant sludge is partially separated and from which water is allowed to pass to sand filters, thence to storage tanks and distribution system. Process has been in widespread use for many years and involves nothing new or unusual. In many larger water softening plants quicklime has been substituted for hydrated lime because of its greater activity per lb and because it is less expensive in form in which it is usually marketed. To use it successfully, however, it is necessary to pass it through slaking process and to sacrifice considerable accuracy in proportioning thereby. Much larger investment is required in storage, handling, feeding and slaking equip. than is case when using hydrated lime and skill level of operating personnel must be considerably higher. These factors account for fact that use of quicklime is usually confined to plants using more than North Miami. Method has been discovered and applied at North Miami of using quicklime in pulverized form, which eliminates necessity for slaking and preserves all advantages hydrated lime has over quicklime, plus certain addnl. advantages. While cost per ton of material is more than for hydrate, because of its greater activity per lb it costs less per unit of water treated and requires no additional investment for storage, handling, feeding or slaking equip.—*PHEA*

The Use of Aeration as an Aid in the Clarification of Waters by Means of Aluminum Sulfate. G. Cambosu. Igiene Mod. (Italy), **47**:359 ('54). Effect of air

(*Continued on page 74 P&R*)

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(*Continued from page 72 P&R*)

blowing on process of clarification of naturally turbid H_2O with $Al_2(SO_4)_3$ (I) on alk. side was studied. It was found aeration may reduce time required for formation and growth of $Al(OH)_3$ flocs and sedimentation time to ¼ time which would be required if H_2O and I are simply mixed. Also aeration has I-sparing action, making possible use of ¼ amt. of I necessary to produce same results as would be obtained without aeration. To obtain these results, however, air-blowing must be done simultaneously with addn. of I to H_2O and provided that there is present min. crit. amt. of $Al(OH)_3$.—*CA*

Preparation of Coagulants From Ashes of Certain Coals. J. GANCZARCZYK. Gaz, Woda i Tech. Sanit. (Poland), 27:292 ('53). Coagulants are prepd. by activation of crushed ashes with concd. H_2SO_4, drying, and 3–5 days of ripening. Process is protected by Polish patent 36,097. In this work, water having coloration of 60 mg Pt/l, O consumed 10 mg O/l, turbidity 7 mg SiO/l, pH 7.4, was subjected to coagulation with $Al_2(SO_4)_3$ (I) and with coagulants obtained from coal ashes (II). Compn. of ashes was: Al_2O_3 18.7–26.6; Fe_2O_3 5.8–12.8; SiO_2 41.2–43.8; CaO 0.9–8.4; substances sol. in 10% H_2SO_4 2.0–35.7; loss in calcination 7.0–21.4%. I gave reduction of color down to 5 mg Pt/l, O consumed to 6 mg/l, and pH to 6.5. II gave, resp.: less than 5 mg Pt/l, 3.5–5 mg/l, and 6.1–6.5. Coagulates produced by II are of 3 times smaller vol. and of easier sedimentation than those produced by I. II have remarkable sorption power. Necessity of developing method for obtaining II of uniform compn. in industrial application is stressed.—*CA*

AQUATIC ORGANISMS

Energy Fixation and Utilization by Natural Communities in Western Lake Erie. J. VERDUIN. Ecology 37:40 ('56). Photosynthesis (I) and respiration (II) rates in natural water and in water samples concd. by screening through No. 25 silk-bolting

(*Continued on page 76 P&R*)



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(*Continued from page 74 P&R*)

cloth were measured during various seasons by using pH changes as index of CO_2 change. During autumn, dim light was used more efficiently than in spring. **I** at optimal light gave avg. value of 5 micromole CO_2 absorbed/10 μl/hr and 1.6 micromole/mg ash-free dry wt./hr. Filtering removed about $\frac{1}{3}$ of **I**. Under completely natural conditions, avg. of 68 micromole CO_2 was absorbed/l H_2O/day at 23°, decreasing to 10 at 0°. Bottom fauna are mainly mussels (78%) and insects (16%), yielding avg. net wt. of 85 g/sq m (excluding mussel shell). **II** of the latter avgd. 20 micromole CO_2/g/hr, whereas for the former **II** was about 1. It is estd. that bottom fauna contributes about 4% to total **II**/sq m of H_2O.—*CA*

Direct Oxygen Consumption by Effluent Discharge in Lakes. E. A. THOMAS. Schweiz. Ver. Gas-u. Wasserfach Monats-Bull. (Ger.), **35**:119 ('55). Oxygen consumption in recent yrs. in Pfaffiker and Greifen lakes is discussed; graphs and effect of O consumption on flora and fauna are given. It is concluded that effect of effluents on O content near surface is insignificant owing to compensating aeration. However, indirect effect of effluent attributed to excessive fertilization of lake water (phosphate addn. particularly) is quite noticeable, especially in lower depths of the lakes.—*CA*

Analysis of Phytoplankton Yields in Relation to Certain Physical and Chemical Factors of Lake Michigan. R. E. GRIFFITH. Ecology, **36**:543 ('55). Frequent collections of nearshore water of Lake Michigan at Northwestern Univ. campus were taken during 1953–54. Data were collected on certain phys. and chem. factors in addn. to quant. anal. of phytoplankton. DO was highest in Apr., 1953, and Mar., 1954, with peaks of 12.6 ppm, and lowest (4.6 ppm) in Aug. and Dec. There appears to be no correlation between O satn. curve and that of total plankton. Free CO_2 did not appear until Jan., 1954, and level of 1 ppm increased to 7 ppm in Feb., coincident with heavy snow and ice cover. Bicarbonate highs of 135 ppm were noted in May and Feb., and no carbonate was found in Jan. through Mar. (during rest of yr approx. 20 ppm was present).—*CA*

(*Continued on page 78 P&R*)

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(*Continued from page 76 P&R*)

DISINFECTION

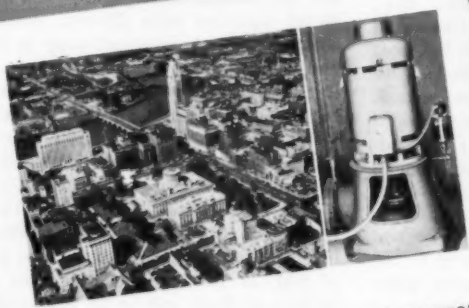
Sterilization of Water by Use of Chlorine and Ultrasonic Waves. M. J. VERAIN. U.S., 2 (Sep. 13, '55). App. is described in which both inherent germicidal activity of ultrasonic waves and their ability to speed up hydrolysis of Cl are used in sterilization of water. Ultrasonic waves impart to water oxidizing power which can be measured by oxidation of *o*-toluidine. Ultrasonic waves decrease pH of water, at which time oxidizing properties develop. Water is first run into chlorination tank and then into open-top tank sealed at bottom by thin metallic membrane of ultrasonic generator. Optimum frequency range for ultrasonic vibrations is 400–1000 kc/sec. Required energy is about 10 w/sq cm of section of ultrasonic beam.—*CA*

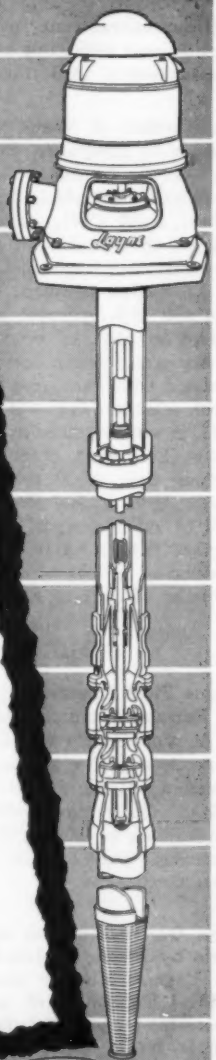
Bactericidal Efficiency of Quaternary Ammonium Compounds (Q.A.C.) in Different Waters. C. W. CHAMBERS ET AL. Public Health Rpts., 70:545 ('55). Many waters interfere with bactericidal action of Q.A.C. In this study, hard waters have been shown to interfere seriously. Bicarbonates, sulfates, and chlorides of Ca and Mg appear to be primary cause of interference. $Fe(HCO_3)_2$ interfered to moderate degree, but this interference was minimized when Fe was oxidized. Natural waters in which bulk of mineral content was $NaHCO_3$ and $KHCO_3$ did not seriously interfere with germicidal action of Q.A.C. When such waters were boiled, most of bicarbonates were converted to normal carbonates with no apparent change in interference. Lime and partial zeolite softening removed considerable portion of interference from hard water used in tests. $Na_4P_2O_7$ and tetra-Na ethyl-

(*Continued on page 80 P&R*)



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As Columbus, capital city of the great state of Ohio, grew—so did its demand for water.

Six Layne drilled wells and six Layne vertical turbine pumps with a potential capacity of ten million gallons of water per day now serve the city's eastern section. This provides adequate supply for future growth.

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(*Continued from page 78 P&R*)

enediaminetetraacetate reduced interference of this water sufficiently to offer promise for use in practical applications.—*CA*

Disinfection of Water with Solid Compounds of Hydrogen Peroxide. M. Polster & Z. Bochorak. Ceskoslov. Hyg., Epidemiol., Mikrobiol., Imunol. (Czechoslovakia), **3**:291 ('54). Investigation has been made of effectiveness of 2 solid addn. compds. of sodium bicarbonate and hydrogen peroxide in disinfection of water. Compds. contained 25.4 and 24% hydrogen peroxide; was stabilized by addn. of silica gel. 1-l samples of tap water contg. test compds. were inoculated with *Esch. coli* in concn. of 6,000–8,000 organisms/ml, and bact. content was detd. in samples taken at intervals up to 300 min. One compd. produced complete disinfection after 20–30 min when present in concn. of 0.1%, and after 2 hr in concn. of 0.01%; other compd. was slightly less effective. Effect was enhanced when decomposition of hydrogen peroxide was retarded by addn. of trace of silver nitrate.—*BH*

POLLUTION

Some Field Observations of Radioactivity at Estrela Mountain. M. X. de Morais & J. M. Correia Neves. Publs. museu e lab. mineral. e geol. e centro estud. geol. univ. Coimbra, Mem. e notic. (Spain), **39**:60 ('55). Observations with Geiger counter gave values of 0.05 mr./hr except at Neve fountains, where values up to 0.5 mr./hr were noted.—*CA*

The Decontamination of Water in Wartime by Means of Ion-Exchange Resins. G. Lalli. Minerva Med. (Ital.), **2**:1372 ('54). Possibility of using ion-exchange resins for removal of radioisotopes from water is briefly discussed. Investigation of biol. purification was carried out by passing highly pold. Tiber R. water through 60-cm column contg. 150 ml of wet cationic resin (Amberlite IR-120-H) (**I**) at rate of 0.2 ml/ml of resin. For first 200 ml water/ml resin filtered, pH was 2.5, bact. removal (total plate count at 37°) avgd. 99.7%; removal of thermoresistant organisms varied between 60 and 90%, and removal of *Clostridium perfringens* was approx. 90%. Subsequent filtration samples displayed rise in pH and sharp decrease in bacteria removals. With anion-exchange resin (IRA-400-OH) (**II**) bact. reduction ranged from 99 to 100% and pH ranged from 12.1 to 11.0 for first 80 ml water/ml resin filtered. Further filtration of water produced drop in pH and removal of biol. agents. Column contg. equal parts of **I** and **II** yielded over 99.5% bact. reduction for first 100 ml water/ml resin with final filtrate pH of approx. 5.5. Suspensions of *Esch. coli* in distd. water with varying concns. of NaCl (0.0001–0.01 *M* NaCl) were passed through **I** and **II**. Max. removal of 99.2% of *Esch. coli* with resulting pH of 2.1 was effected by **I** in presence of 0.01 *M* NaCl. Max. removals (above 99.7%) of *Esch. coli* by **II** was observed in sample contg. 0.01 *M* NaCl with filtrate pH 11.4 and sample contg. no NaCl with filtrate pH 5.9.—*CA*

Limitations of Water Treatment Methods for Removing Radioactive Contaminants. C. P. Straub. Pub. Health Repts. **70**:897 ('55). Conventional water treatment processes may remove varying percentages of radioactive contaminants from water. However, percentage removal values have little meaning unless they are related to initial concn. of radioactive materials present and to max. permissible concn. value prescribed for individual radioisotope. Generally speaking, unless initial concn. is very low—certainly several orders of magnitude below microcurie ml range—water treatment processes will be ineffective for reducing radioactive contaminants to acceptable safe limits. Radioactive materials should be retained as close to their source of production as possible. At present, practice is to store materials in tanks. Transfer of radioactivity from liquid to solid phase does not eliminate problem since suitable storage facilities still must be provided for radioactive sludges, but it does considerably reduce area of potential contamn. To protect large centers of population that depend on sources of water which may become contamd. with radioactive materials, plans should be made now for

(*Continued on page 82 P&R*)

HOW HIGH IS HIGH?

We are being pressed everyday by engineers to take a position on highness, i.e., highness of throughput rate in cold process clarification and softening plants. The facts are that the Graver solids-contact Reactivator® can operate and has operated successfully at rates of flow of 2.0—2.5 gpm/sq. ft. on various water supplies. However, we generally recommend that plant and consulting engineers design such units to meet specific conditions and at more conservative flow rates, allowing for reserve capacity to accommodate changes in operating conditions, demands for increased flow or changes in water composition and temperature. We believe this to be sound engineering practice — a belief that has been borne out in hundreds of successfully operating Reactivator installations treating a variety of raw water supplies. Our policy on this subject is outlined in Technical Reprint T-135. Write for a copy to: Municipal Dept. M-212, Graver Water Conditioning Co., Division of Graver Tank & Mfg. Co., Inc., 216 West 14th Street, New York 11, New York.

(*Continued from page 80 P&R*)

supplying water from noncontamd. sources. For this purpose, existing ground water supplies may be used; other interconnected water supplies may be piped in; or special provisions should be made to bring in water from outside area. These precautionary measures are applicable, however, only when radioactive contamn. is not great enough to constitute ext. hazard to man. 19 references. —*CA*

Natural Removal of Atmospheric Pollution During Fog. A. R. MEETHAM. Quart. J. Roy. Meteorol. Soc. (Br.), **80**:96 ('54). Smoke and SO_2 mols. may, fortunately, have shorter lifetime during foggy weather than in normal weather. Carefully revised calcns. for mass emitted, mass deposited, mass blown to sea, and avg. life over land in United Kingdom gives avg. lifetime of 28 hr for smoke and 8.75 hr for SO_2, and an emitted mass of 2.3 and 5.0 million tons/yr., a deposited mass of 0.8 and 3.9 million tons/yr., and an amt. of 1.5 and 1.1 millions tons/yr. blown to sea, for smoke and SO_2 resp. Conditions during London fog of Dec. 5–9, 1952, when 700 tons of smoke and 1,400 tons of SO_2 were emitted per day in an area of 450 sq. mi. around London, are analyzed, leading to conclusions that concns. of 6.2 ppm of SO_2 (8.0 mg/cu m) would be produced in day, when actually only 2.1 mg/cu m was detected. This indicates that lifetime of SO_2 mol. was only 6 hr (and of smoke 13 hr). It is further shown that much of this shortening of lifetime can be accounted for by combination with fog particles and eventual pptn., but possibly even more important by combination with smoke particles (or aggregates of smoke particles which are seen to float through air during fogs), since it would be 10–100 times as easy for SO_2 to stick to smoke particle as to fog droplet. Standard volumetric measuring instrument does not measure SO_2 attached to smoke,

(*Continued on page 86 P&R*)

ELEVATED STEEL TANKS

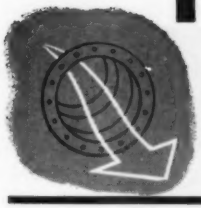
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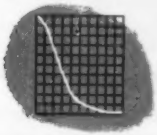
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Rotovalve 55% closed at 25% stroke, and 92% closed at 50% stroke. In comparison, gate valves only 18% closed at 25% stroke and 43% closed at 50% stroke.



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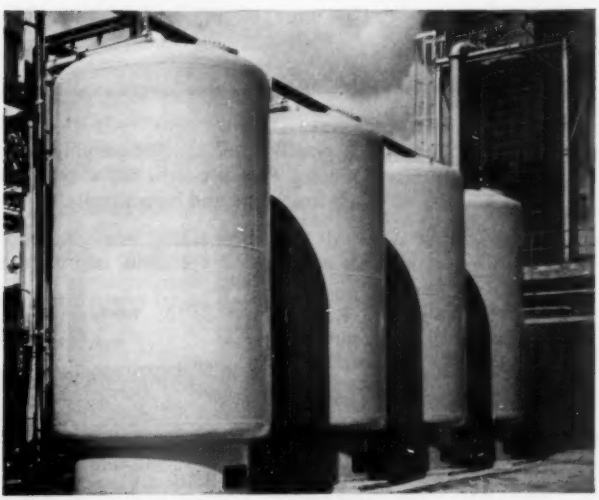
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Growing U. S. cities and towns are faced with using lower-grade water. Results: increased hardness, turbidity, iron, high CO_2 "aggressive waters", other problems . . . complaints from homeowners, businesses, industries.

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AUTOMATIC CONTROLS to ensure optimum results are designed, assembled, wired and tested by Permutit.

(Continued from page 82 P&R)

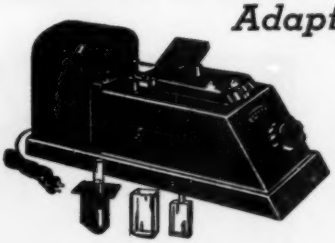
since smoke is filtered out before air passes through H_2O_2 soln. which collects SO_3, and amt. stopped by filter is small. This instrument also fails to collect particles falling faster than 0.3 cm/sec, but human lung can collect both the fog and smoke particles contg. SO_2 or its derivs., not to mention free SO_3 mols. Oxidation to H_2SO_4 may prove to be source of danger to human life in such fogs, which, were it not for fallout and eventual drift of remainder to sea, would prove far more deadly.—*CA*

Determining Concentration of Airborne Plutonium Dust. G. W. C. TAIT. Nucleonics, **14**:53 ('56). Airborne particles are sepd. into 2 groups consisting of greater and less than 1 μ diam. with annular impactor operating at sampling rate of 1,000 l/min. Standard counting tray is lightly greased and placed over orifice of impactor. Air is drawn through impactor for 2–5 min by means of vacuum cleaner and tray removed and counted with α-sensitive scintillation counter. Impactor has sampling efficiency of approx. 90% for dusts generated by normal tech. processes and low 10% efficiency for Rn-decay products and is suitable for sampling airborne Pu or long-lived α emitters of high toxicity in presence of high background of Rn or Th decay products. Application to sampling β- or γ-active particles, other than daughters of gaseous fission products, required only modification of final counting procedure.—*CA*

Treatment of Water and Sewage by Ionizing Radiations. C. G. DUNN. Sew. Ind. Wastes, **25**:1277 ('53). Results of experimental irradiation treatment on bacteria in water and sewage indicate that sterilization can be achieved by exposure to Co^{60} and cathode ray sources, but it occurs too slowly to be of practical value at present. —*PHEA*

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Section Meetings

Kentucky-Tennessee Section: The 28th annual meeting of the Section, in joint session with the Kentucky-Tennessee Industrial Wastes & Sewage Works Assn., set a new registration record of 317, including 46 ladies. Sessions were held at the Patten Hotel, Chattanooga, Tenn., Sep. 17–19, 1956. Joint sessions were held on Monday, with separate sessions of the two organizations on Tuesday and Wednesday mornings. At the opening session the group was welcomed by Mayor P. E. Olgiati of Chattanooga and the response was given by Elmer Smith, general superintendent of municipal utilities, Owensboro, Ky. President Paul Weir brought greetings from AWWA. [A list of the technical-session papers will appear in the December 1956 JOURNAL.]

On Monday evening those members with a nautical turn took a boat ride to Chickamauga Dam and through the lock to Chickamauga Lake. The annual banquet on Tuesday night was highlighted by the naming of Julian R. Fleming, director of sanitary engineering, Tennessee Dept. of Public Health, for the Fuller Award and the presentation of incoming officers of the Section.

Ladies' entertainment consisted of a brunch and chartered-bus tour on Monday, and a luncheon at the Signal Mountain Country Club with a style show on Tuesday.

On Wednesday, members were the guests of W. S. Dickey, Clay Mfg. Co., for an old-fashioned southern barbecue and an inspection trip through the plant.

J. WILEY FINNEY JR.
Secretary-Treasurer

Michigan Section: The Michigan Section held its eighteenth annual meeting in Kalamazoo on Sep. 12–14, 1956, with headquarters at the Burdick Hotel. Kalamazoo is the center of a great paper industry and proved to be a very interesting place to hold a water works meeting. Everything possible was done to make it very worthwhile and enjoyable. Mayor Glenn S. Allen Jr. displayed a keen interest in water utilities in his welcoming address. [A list of the technical papers presented will appear in the December JOURNAL.]

All those at Thursday evening's banquet appreciated the clever wit of Chairman Claud Erickson. The banquet speaker, Irv Wermont, had everyone spellbound and pleasantly entertained with his demonstration of memory. Thirty-eight members received the Edward Dunbar Rich Service Award for 25 years of meritorious and faithful service in providing and maintaining a safe and adequate water supply. Robert L. McNamee was nominated for the Fuller Award. Tribute was also paid to Earl E. Norman, of Kalamazoo, the Section's first chairman and director, who was unable to attend because of his health.

The manufacturers' representatives and the WSWMA proved very gracious hosts at a smoker on Wednesday night and a cocktail hour on Thursday night, and furnished refreshments after the banquet.

The 82 ladies attending enjoyed a very interesting program provided by the local Ladies Committee. The total registration for the meeting was 360.

T. L. VANDER VELDE
Secretary-Treasurer

(*Continued on page 90 P&R*)



CITY OF BEREA, OHIO *cuts costs*

New Cochrane SOLIDS-CONTACT REACTOR *combines*

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The relatively hard, turbid Rocky River supply for the city of Berea, Ohio, is quickly reduced in hardness to approximately 3.5 gr/gal and to a turbidity of less than 10 ppm by the Cochrane Solids-Contact Reactor shown above. An existing concrete basin 28′ square x 15′ deep was modernized by conversion to the Solids-Contact type. Using hydrated lime, soda ash and alum, the Reactor treats over 2,000,000 gpd at surprisingly low cost.

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Section Meetings

(Continued from page 88 P&R)

Missouri Section: The eleventh annual meeting of the Missouri Section was held in Jefferson City on Sep. 30–Oct. 2, 1956. There was a total registration of 275, which exceeded all past records by fifteen. Vice-President Fred Merryfield represented the Association. During one of the technical sessions he gave a very interesting talk titled "Water—the Great Catalyst." At the annual banquet he nominated Ellsworth L. Filby, consulting engineer, Black & Veatch, Kansas City, for the Fuller Award. Service citation awards of the Missouri Section were presented to George S. Russell, consulting engineer, Russell & Axon, St. Louis; and Frank E. Dolson and Herbert O. Hartung, St. Louis County Water Co., University City.

William S. Foster, editor, *American City Magazine*, gave a most outstanding discussion on water and sewage works administration. Mr. Foster emphasized the necessity for, and outlined a number of important criteria in, establishing good public relations. [A complete list of the technical papers presented will appear in the December 1956 JOURNAL.]

Dinner was served to 141 members and guests at a banquet on Tuesday evening, which concluded the meeting. The speaker was Curtis L. Wilson, dean, Missouri School of Mines, Rolla.

W. A. KRAMER
Secretary-Treasurer



Fuller Award Nominee Ellsworth L. Filby looks on as (left to right) George S. Russell, Frank E. Dolson, and Herbert O. Hartung examine service citations presented to them at the Missouri Section Meeting.

(Continued on page 92 P&R)



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Section Meetings

(Continued from page 90 P&R)

North Central Section: The 40th annual meeting of the North Central Section was held at the Hotel Lowry, St. Paul, Minn., Sep. 12–14, 1956. The total attendance was 183, including 26 ladies. The outstanding features of the meeting were the high caliber of papers presented, the unusual attendance at the sessions, and the extreme interest displayed. An apparently popular innovation was opening the meeting officially with a noon luncheon, which was made the occasion for a welcoming speech by Mayor Joseph E. Dillon and a most timely and inspiring address by Commissioner Milton Rosen, who was warmly welcomed back to the Association as president of the St. Paul Water Board. [The papers presented at the technical sessions will be listed in the December 1956 JOURNAL.]

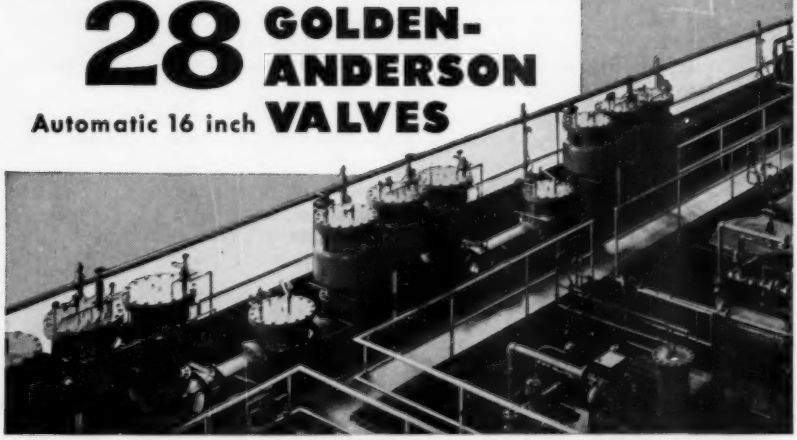
An annual event is the Section Business Luncheon, which is always well attended. The luncheon is followed by committee reports and election of officers. On that occasion also, it is the practice to hear from the official representative of AWWA. This year the Section was honored by the presence of Vice-President Fred Merryfield, who won the hearts of all by his charming manner. His talk was of unusual interest, highly instructive and entertaining.

The meeting closed Friday evening with the Annual Banquet, followed by an especially fine entertainment. No Fuller Award was voted this year, but Carl Flack, registrar of the St. Paul Water Dept., was given the Finch Award for outstanding service rendered to the Section. New officers elected and pre-

(Continued on page 94 P&R)

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"The most modern pumping station in the world today"

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Automatic 16 inch VALVES



4-page folder describing this installation gladly sent on request.
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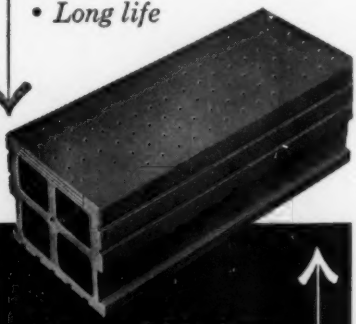
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Section Meetings

(Continued from page 92 P&R)

sented at the Annual Dinner were: H. H. Behlmer (superintendent, Fargo, N.D., Water Dept.), chairman; M. H. Lubratovich (manager of water, gas and sewage treatment, Duluth, Minn.), vice-chairman; Paul Buccowich Jr. (superintendent of water, Ely, Minn.), trustee; and L. H. Coult (Water & Light Commission, Fairmont, Minn.), national director. Under the leadership of Mel Bischoff, Flox Co., Minneapolis, as general chairman—and his able assistants—the meeting was highly successful.

L. N. THOMPSON
Secretary-Treasurer

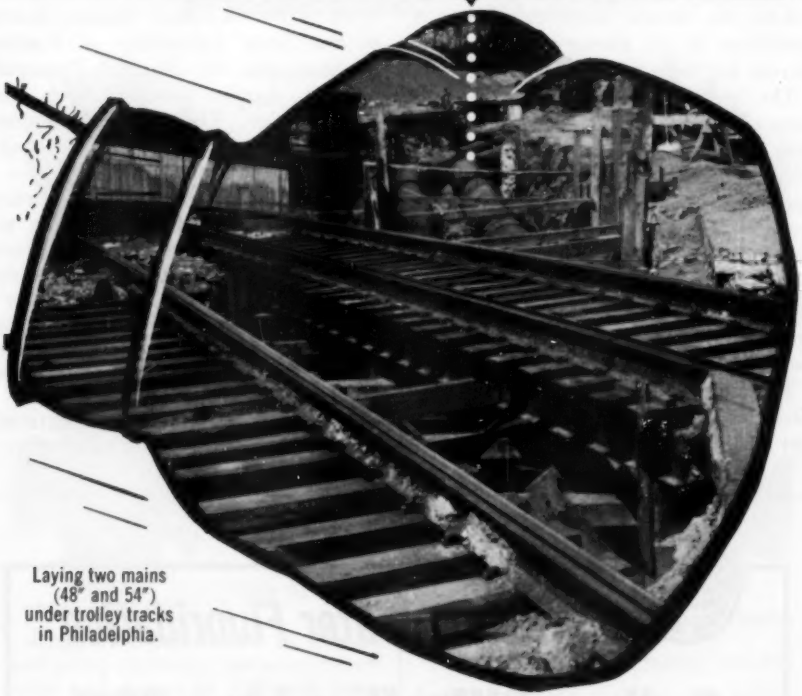
Wisconsin Section: The 35th annual meeting of the Wisconsin Section was held in LaCrosse on Sep. 26–28, 1956, with 296 persons in attendance. Sessions were held in the new municipal auditorium, and registration and other functions at the Hotel Stoddard. Officers elected for the next year are: chairman—James E. Kerslake, Milwaukee; vice-chairman—Harvey E. Wirth, Madison; secretary-treasurer—Harry Breimeister, Milwaukee; trustee—Arthur J. Jark, Jefferson; and trustee ex officio—Bruno J. Hartman, Sheboygan; Jerome C. Zufelt, Sheboygan, was elected director in 1954. James E. Kerslake was nominated for the Fuller Award.

Registration began on Wednesday morning, Sep. 26. In the afternoon LaCrosse Mayor Milo G. Knutson extended the city's official greeting and spoke of the challenge to the water works industry created by the ever increasing demand.

A highlight of the meeting was the Leon A. Smith Memorial Program—a tribute to the late secretary, whose untimely death on May 11, 1956, while attending the Annual Conference in St. Louis, so shocked his many friends in the profession. Dr. M. Starr Nichols, of Madison, presented a memorial resolution of the Board of Water Works & Sewerage Commissioners of that city,

(Continued on page 96 P&R)

HOW STEEL PIPE ROLLS with the PUNCH...



Laying two mains (48" and 54") under trolley tracks in Philadelphia.

You can rely on strong resilient, steel water pipe to "roll with the punch" regardless of what that "punch" might be. Steel pipe not only has the resilience to give under soil movement, but is also immune to surface vibrations caused by heavy vehicular or rail traffic.

This quality, together with its great beam strength and its remarkable shock-resistance, means that you can rely on steel water pipe to give you many years of dependable service.

When you add to all this its economy of installation and upkeep together with the complete resistance to corrosion given by a lining and coating of coal tar enamel, you can see why we say—you're smart to specify STEEL pipe.

"WHEREVER WATER FLOWS—STEEL PIPES IT BEST"

STEEL PLATE FABRICATORS ASSOCIATION

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(Continued from page 94 P&R)

and President Paul Weir offered an expression of deep sympathy to Smith's family and friends. Standing in silent tribute the Section members adopted a resolution in his memory, and a copy thereof has been sent to Mrs. Smith.

The technical sessions adjourned at noon on Friday, Sep. 28. An innovation this year was a 15-min break at the Thursday and Friday morning sessions, during which coffee and pastries were served through the courtesy of the Local Arrangements Committee. The success of this practice warrants its continuation at future meetings. [A list of the papers presented will appear in the December JOURNAL.]

The annual banquet on Thursday evening was attended by 249 persons. Section Chairman Bruno J. Hartman officiated at a very short business session, which included the presentation of Life Membership certificates by President Weir to Dr. M. Starr Nichols, director of the State Laboratory of Hygiene, Madison, and Dr. Bernard Domogalla, director, Applied Biochemists & Associates, Butler. Then followed the distribution of numerous door prizes and a very excellent floor show.

The ladies' program, which attracted 81 women, included a sightseeing tour and visit to the LaCrosse Rubber Works, a scenic boat trip up the Mississippi River, and a luncheon and card party at the Cerise Club. A coffee hour each morning provided an ideal opportunity for the ladies to meet and become acquainted.

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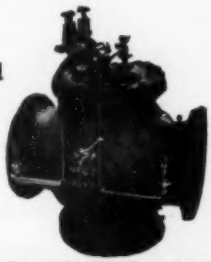


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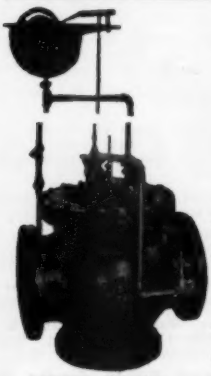
Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

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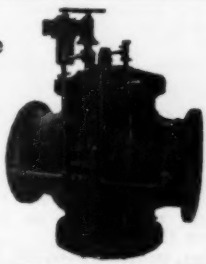


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NEW MEMBERS

Applications received Sep. 1–30, 1956

Abernathy, Henry Earl, Relay Test Helper, Safety Dept., Utilities Board, 626 S. Gay St., Knoxville, Tenn. (Oct. '56) *MD*

Ainsworth, Breeman N.; *see* Gwinett County Water System

Amar, Fidele Henry, Supt., Southwest Water Co., 16340 E. Maplegrove Ave., Puente, Calif. (Oct. '56) *M*

Arthur, Robert, Asst. Prof., Rose Polytech. Inst., Terre Haute, Ind. (Oct. '56) *MRPD*

Balch, William Thomas, Mgr., Water Resources Dept., Kern County Land Co., Box 380, Bakersfield, Calif. (Oct. '56) *MR*

Bauhahn, Elmer E., Engr., Div. of Municipal Water & Light, 1101 Monroe Ave., N.W., Grand Rapids, Mich. (Oct. '56) *D*

Bodden, E. L., Supt., Farmers Gin Co., Falls City, Tex. (Oct. '56) *M*

Bonds, Harry C., Dist. Mgr., Layne & Bowler Pump Co., Box 31, Hastings, Neb. (Oct. '56) *MRD*

Bowlby, Robert L., Sales Engr., Rockwell Mfg. Co., New York, N.Y. (Oct. '56)

Boyer, Robert Woodfin, Supt., Water Treatment Plant, Sparta, Ga. (Oct. '56)

Brainard, Frank Samuel, 246 Palm St., Hartford, Conn. (Oct. '56) *MD*

Brow, Dan, Supt., Norton Township Water & Sewer Dept., 4805 Henry St., Muskegon, Mich. (Oct. '56) *D*

Brown, Marvin B., Utilities Mgr., Newcastle, Ind. (Oct. '56) *MRPD*

Cahill, William J.; *see* Tuxedo Park (N.Y.)

Carley, Donald Oliver, Civ. Engr., Milner W. Carley & Assocs., 500 W. Hwy. 96, St. Paul 13, Minn. (Oct. '56) *MPD*

Clark, William C., Jr., Sales Repr., Plastic Pipe Div., Goodall Rubber Co., 5 S. 36th St., Philadelphia, Pa. (Oct. '56) *D*

Conley, Walter Robertson, Jr., Engr., General Electric Co., Richland, Wash. (Oct. '56) *P*

Conrad, William F., Sales & Service Engr., Heldt-Monroe Pump Co., Evansville, Ind. (Oct. '56)

Consolidated Water Corp., Arthur L. Stephenson, Vice-Pres., 206 S. Jefferson St., Mexico, Mo. (Corp. M. Oct. '56) *MP*

Cooper, William Roy, Pumping Supt., Mahoning Valley San. Dist., Box 298, Youngstown, Ohio. (Oct. '56) *M*

Cope, Robert J., Sales Engr., Mueller Co., 109 Louisiana Ave., Lexington, Ky. (Oct. '56) *D*

Cotterell, J. L., Asst. San. Inspector, 308 C St., Idaho Falls, Idaho (Oct. '56) *P*

Crawford, Julius P., Supt., Water & Electric Dept., Dyersburg, Tenn. (Oct. '56) *MD*

Crawley, Evan, Mayor, City Hall, Greencastle, Ind. (Oct. '56) *MRPD*

Cutler, L. W., Pure Ice, Ltd., Box 505, Nassau, Bahamas (Oct. '56)

Cunningham, Leo L., Prin. Engr., Burns & McDonnell Eng. Co., 95th & Troost, Kansas City, Mo. (Oct. '56) *MRPD*

Curtis, Harry Edward, Mgr., Nitro Area, West Virginia Water Service Co., 22nd St., Nitro, W.Va. (Oct. '56) M

Davis, Alan G., City Mgr., Greenville, Mich. (Oct. '56) *MD*

Dehem, George A., Sr. Assoc. Mech. Engr., Dept. of Water Supply, 735 Randolph, Detroit, Mich. (Oct. '56) *MPD*

Dianda, Robert Joseph, Sales Engr., Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa. (Oct. '56) *MD*

Donaldson, John J., Salesman, Keasbey & Mattison Co., Ambler, Pa. (Oct. '56) *D*

Duke, Donald T., Asst. Supt., Water Dept., East Liverpool, Ohio (Oct. '56)

Eborn, W. N., Asst. Supt., Middlesex Water Co., 52 Main St., Woodbridge, N.J. (Oct. '56)

Egbert, Donald Carlyle, Engr.-Mgr., Southeastern Oakland County Water Authority, Box 184, Royal Oak, Mich. (Oct. '56) *M*

Elder, George R., Jr., Supt. of Operations, Artesian Water Co., 501 Newport & Gap Pike, Newport, Wilmington 4, Del. (Oct. '56) *M*

Elkins, Mahlon Franklin, Supt., Water Works Corp., Harleyville, Ala. (Oct. '56) *MPD*

Federal Telephone & Radio Co., Div. of International Telephone & Telegraph Corp., Frank Weber, Sales Repr., 100 Kingsland Rd., Clifton, N.J. (Assoc. M. Oct. '56)

Fergusson, Robert A.; *see* Rust-Oleum Corp.

Furbee, George A., Mgr., Electric Utilities, 10 N. Center St., Flora, Ind. (Oct. '56) *MPD*

Gaisbauer, Edward F., Sales Repr., Waterous Co., 80 E. Fillmore Ave., St. Paul, Minn. (Oct. '56)

Garcia, Eduardo, Civ. Engr., Howard Humphreys & Sons, Victoria Station House, Victoria St., London S.W. 1, England (Jan. '56) *PD*

Garsaud, Octave P., Secy., Board of Comrs., East Jefferson Water Works Dist. No. 1, 3600 Jefferson Hwy., New Orleans 21, La. (Oct. '56)

Gibbing, Frank, Supt. of Water & Sewage, Utica, Mich. (Oct. '56)

Gott, James F., Water Supt., Town of Owasco, 2 Bristol Ave., Auburn, N.Y. (Oct. '56) *MRPD*

Graham, Douglas S., Salesman, Keasbey & Mattison Co., Ambler, Pa. (Oct. '56) *D*

Graham, Ralph E., Hydr. Engr., Water Dept., Balboa Park, San Diego, Calif. (Oct. '56) *M*

Grathwol, A. W., Supt., Water Dist., City Bldg., Sandusky, Ohio (Oct. '56)

Griesbach, Paul, Meter Repair & Testing, Norton Township Water & Sewer, 3146 Henry St., Muskegon, Mich. (Oct. '56) *M*

Groce, Aaron C., Salesman, Southern States Chem. Co., 25 Peden St., Greenville, S.C. (Oct. '56)

Groves, Virgil D., Gen. Mgr., Pico Water Dist., 4843 S. Church St., Pico, Calif. (Oct. '56) *M*

Gursky, Peter P., Plant Engr., Onondaga County Water Authority, 1240 Wolf St., Syracuse, N.Y. (Oct. '56) *MRPD*

Gwinett County Water System, Breeman N. Ainsworth, Mgr., 127 Perry St., Lawrenceville, Ga. (Munic. Sv. Sub. Oct. '56) *MPD*

Hager, Howard, Jr., Sales Repr., Keasbey & Mattison Co., Ambler, Pa. (Oct. '56) *D*

Harrington, Kenneth P., Contractor, Shamrock Eng., 865 S. Lake St., Gary, Ind. (Oct. '56) *PD*

Hawker, Fred M.; *see* Tipton (Iowa)

Heggie, Glen D., Sr. Assoc. Engr., Dept. of Water Supply, 735 Randolph, Detroit 26, Mich. (Oct. '56) *MD*

Herod, Don; *see* Princeton (Ind.) Water Co.

Holte, Hilmer M., Foreman, Water Supply, Office of Post Engr., APO 949, Seattle, Wash. (Oct. '56) *MP*

Indzonka, Louis F.; *see* New Windsor (N.Y.) Water Dist.

Ivey, Jasper W., Pres. & Mgr., Ivey Chem. Co., Inc., Box 569, Greenville, S.C. (Oct. '56)

Jasper Utility Service Board, Robert W. Wade, Supt., Jasper, Ind. (Munic. Sv. Sub. Oct. '56) *MRPD*

(Continued on page 100 P&R)

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(Continued from page 98 P&R)

Jeffrey, W. D., Pres., W. D. Jeffrey Constr. Co., Inc., Fort Smith, Ark. (Oct. '56)

Johnson, Ray; *see* Oakley County (Calif.) Water Dist.

Jones, John Paul, Sales Engr., Rockwell Mfg. Co., Box 88, Beattyville, Ky. (Oct. '56)

Kase, Jack, Salesman, Layne-Northern Co., Inc., 401 S. Delorenzi, Mishawaka, Ind. (Oct. '56) *P*

Keegler, Kenneth K., Sales Repr., Diamond Alkali Co., 9 Woodburn Court, Bowling Green, Ohio (Oct. '56)

Kelly, Ralph D., Sales Mgr., Kelly Supply Co., Grand Island, Neb. (Oct. '56) *RD*

Knapp, Alden P., Officer, E. R. Knapp & Sons, Inc., Box 295, Rochester, Ind. (Oct. '56) *D*

Knapp, Paul; *see* Ohio Oil Co.

Knorr, Warren G., Chemist, Water Treatment Plant, Mansfield, Ohio (Oct. '56) *MRP*

LaMarre, Jennings W., Chemist, Water Treatment Plant, Alpena, Mich. (Oct. '56) *P*

Landers, Luke B., Foreman, Water Works, 651—14th St., Atlanta, Ga. (Oct. '56) *D*

Litz, G. Marvin, Assoc. Civ. Engr., Dept. of Water & Power, 316 W. 2nd St., Los Angeles 12, Calif (Oct. '56) *MRD*

Ljungren, Vernon L., Munic. Engr., Milner W. Carley & Assocs., 500 W. Hwy. 96, St. Paul 13, Minn. (Oct. '56) *PD*

Lowe, Thomas A., Research Engr., Dept. of Metallurgical Research, Kaiser Aluminum & Chem. Corp., Spokane 69, Wash. (Oct. '56) *RPD*

Mautner, Henry M., Dist. Mgr., B-I-F Industries, 20 Vesey St., New York 7, N.Y. (Oct. '56) *PD*

Mautz, Louis P., Sales Repr., Mueller Co., 512 W. Cerro Gordo, Decatur, Ill. (Oct. '56)

McAdams, Basil Alvin, San. Engr., Rader & Assocs., 111 N.E. 2nd Ave., Miami 32, Fla. (Oct. '56) *MRPD*

Meuwissen, William J., Asst. Civ. Engr., Water Dept., 216 Courthouse, St. Paul, Minn. (Oct. '56) *D*

Middleton, Francis M., Chemist, R. A. Taft San. Eng. Center, 4676 Columbia Pkwy., Cincinnati 26, Ohio (Oct. '56) *PR*

Moses, Fletcher E., Water Supt., Kenedy, Tex. (Oct. '56) *M*

Mount Kisco Water Dept., Augustino Sqrulletta, Foreman, 104 E. Main St., Mount Kisco, N.Y. (Corp. M. Oct. '56)

Mullen, Kenneth I., Civ. Engr., James M. Montgomery, 535 E. Walnut St., Pasadena 1, Calif. (Oct. '56) *PD*

Municipal Service Co., H. R. Oglesby Jr., Vice-Pres. & Gen. Mgr., 4625 Roanoke Pkwy., Kansas City 12, Mo. (Assoc. M. Oct. '56)

Murphy, Fred P., Pres., Water Works Board of Trustees, Montgomery, Ind. (Oct. '56) *MRPD*

Nagel, Walter H., Asst. Foreman, Water Supply, Office of Post Engr., APO 949, Seattle, Wash. (Oct. '56) *MP*

New Windsor Water Dist., Louis F. Indzonka, Supt. of Water, Town Hall, New Windsor, N.Y. (Munic. Sv. Sub. Oct. '56) *MD*

Nickerson, Thomas H., Sales Engr., Rockwell Mfg. Co., Box 1181, Atlanta, Ga. (Oct. '56) *MRPD*

Norris, Donald L., Supt., Water Dept., Loogootee, Ind. (Oct. '56) *MPD*

(Continued on page 102 P&R)



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A masterpiece of workmanship and operating simplicity. Your choice of manual, semi-automatic, or fully automatic.

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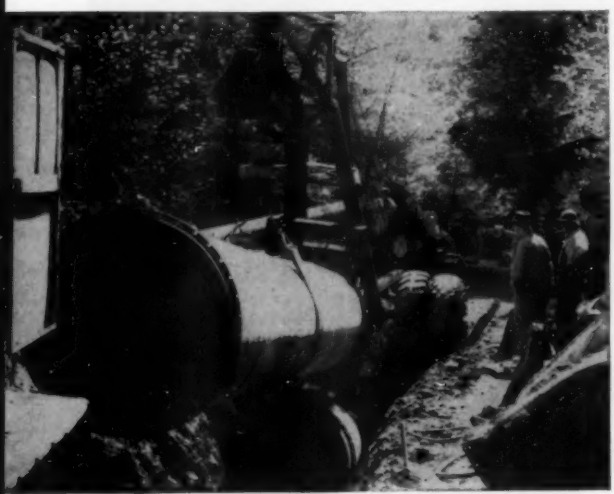
Rugged, hilly Oregon country and tough, widely varied job conditions are ideal for proving the head-and-shoulders superiority of steel water pipe joined with Dresser Couplings.

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And from past experience, cities everywhere find their cost picture is invariably lower with Dresser-Coupled steel construction. Lighter weight steel pipe lowers handling costs. Long, strong pipe lengths call for fewer joints . . . lower installation time. Flexible, yet bottle-tight Dresser Couplings "float" pipe sections in the joints . . . make installations readily adaptable to almost *any* job conditions without a lot of costly specials.

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(Continued from page 100 P&R)

Oakley County Water Dist., Ray Johnson, Pres., Board of Directors, Box 241, Oakley, Calif. (Corp. M. Oct. '56) *MRPD*

Oglesby, H. R., Jr.; *see* Municipal Service Co.

Ohio Oil Co., Paul Knapp, Librarian, Research Center Library, Box 269, Littleton, Colo. (Corp. M. Oct. '56) *R*

Olsen, William Christian, Jr., Engr., W. C. Olsen & Assocs., Box 271, Raleigh, N.C. (Oct. '56) *RPD*

Ostrom, John William, Supt. of Public Works, Richmondville, N.Y. (Oct. '56) *MD*

Payette, Robert C., Supervising Recreation Specialist, Water Dept., San Diego, Calif. (Oct. '56) *RPD*

Perry, John James, Sales Repr., US Pipe & Foundry Co., 448 S. Hill St., Los Angeles, Calif. (Oct. '56) *MD*

Peterson, L. Willard, Resident Engr., Black & Veatch, 4706 Broadway, Kansas City 12, Mo. (Oct. '56) *MRPD*

Plath, Verne E., Sales Engr., Dorr-Oliver, Inc., Stamford, Conn. (Oct. '56) *P*

Princeton Water Co., Don Herod, Water Dept. Supt., City Bldg., Princeton, Ind. (Corp. M. Oct. '56)

Pritchard, Fred J., Foreman, Water Works, 651—14th St., N.W., Atlanta, Ga. (Oct. '56) *D*

Raasch, Dallas G., Engr., Helix Irrigation Dist., Box 518, La Mesa, Calif. (Oct. '56) *M*

Rains, John B., Mgr., Water Works Board, Fort Payne, Ala. (Oct. '56) *M*

Reeser, Wayne, Plant Supt., Princeton Water Co., Princeton, Ind. (Jul. '56) *RPD*

Richardson, D. E., Sr. Design Engr., Facilities Sec., Denver Div., Glenn L. Martin Co., Keith Bldg., Denver, Colo. (Oct. '56) *RP*

Roach, Harley, Supt., Water & Sewer Dept., McMinnville, Tenn. (Oct. '56) *M*

Robbins, Clyde, Supervisor of Constr., Gary-Hobart Water Corp., 103 Ellendale, Hobart, Ind. (Oct. '56) *MRP*

Rose, Burke V. H., Town Engr., Box 35, Vryburg, South Africa (Oct. '56) *MRPD*

Rossi, Anthony Theodore, Supt., North Washington Water & Sanitation Dist., 4901 N. Washington, Denver, Colo. (Oct. '56) *M*

Rossie, William Louis, Jr., Engr. Trainee, San. Eng. Div., State Health Dept., 9th & Main St., Richmond, Va. (Oct. '56) *MRPD*

Russell, Ray H., Design Engr., Marion L. Crist & Assoc., Inc., Union Life Bldg., Little Rock, Ark. (Oct. '56) *P*

Rust-Oleum Corp., Robert A. Fergusson, Pres., 2425 Oakton St., Evanston, Ill. (Assoc. M. Oct. '56)

Scalzitti, Alexander E., Graduate Engr., Univ. of Illinois, 3136 N. Linder Ave., Chicago 41, Ill. (Jr. M. Oct. '56) *P*

Schmucker, R. A., City Chemist, New Ulm, Minn. (Oct. '56) *PD*

Serrick, W. W., Public Health Engr., Provincial Dept. of Health, St. John's, Newfoundland (Oct. '56)

Shalvoy, Walter A., Sales Repr., General Chem. Div., 221 Fir St., Park Forest, Ill. (Oct. '56) *MRPD*

Sharpe, Charles M., Sales Repr., Keasbey & Mattison Co., Ambler, Pa. (Oct. '56) *D*

(Continued on page 104 P&R)

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AND WITH JUST
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(Continued from page 102 P&R)

Shelburn, Ralph, Clyde E. Williams & Assocs., 720 E. 30th St., Indianapolis, Ind. (Oct. '56) *PD*

Shelton, James, Director, Div. of Plumbing, State Board of Health, 1116 Battery St., Little Rock, Ark. (Oct. '56) *MRPD*

Silva, Norberto, Sales Mgr., Empresa Brasileira de Solda Eletrica, Ltd., Avda. Brasil No. 10.335, Rio de Janeiro, Brazil (Jul. '56) *D*

Smiley, Roy D., Fluoridation Consultant, State Board of Health, 1330 W. Michigan, Indianapolis, Ind. (Oct. '56)

Snyder, Charles William, Pres., Snyder Co., Inc., 1432 E. 6th St., Tulsa, Okla. (Oct. '56) *PD*

Sgrulletta, Augustino: *see* Mount Kisco (N.Y.) Water Dept.

Stamps, Cecil Earl, Water Plant Operator, Post Engrs., Fort Chaffee, Ark. (Oct. '56)

Starnes, James E., Mgr., Water & Sewer Board, Scottsboro, Ala. (Oct. '56) *M*

Stephenson, Arthur L.; *see* Consolidated Water Corp.

Stoyak, Michael, Assoc.—Prin. Engr., Burgess & Niple, 2015 W. 5th Ave., Columbus, Ohio (Oct. '56) *PD*

Sundberg, Harold William, Chemist, Metropolitan Water Dist. of Southern California, La Verne, Calif. (Oct. '56) *RP*

Sutherland, J. R., Regional Engr., State Dept. of Health, Essex Bldg., Bank & Plume St., Norfolk 10, Va. (Oct. '56) *PD*

Swindel, George W., Jr., Geologist, Ground Water Branch, US Geological Survey, Box 697, Sylacauga, Ala. (Oct. '56) *R*

Takano, Keiichiro, Promotional Salesman, Lewers & Cooke, Ltd., 404 Piikoi Pkwy., Honolulu 2, Hawaii (Oct. '56) *MRPD*

Talbott, William F., Supt., Water Dept., 305 E. Monroe, Williamsport, Ind. (Oct. '56) *MD*

Taussig, Frederick Foote, Sales Engr., Lock Joint Pipe Co., Box 269, East Orange, N.J. (Oct. '56) *D*

Thomas, John Homer, Sales Engr., Peterson Co., 4949 Colorado Blvd., Denver, Colo. (Oct. '56) *MRPD*

Thompson, Lawrence O., Chemist, Water Treatment Plant, Alpena, Mich. (Oct. '56) *P*

Tipton, City of, Fred M. Hawker, 407 Lynn St., Tipton, Iowa (Munic. Sv. Sub. Oct. '56) *MD*

Tuxedo Park, Village of, William J. Cahill, Supt of Public Works, Tuxedo Park, N.Y. (Munic. Sv. Sub. Oct. '56) *MRPD*

Vansant, Robert E., Civ. Engr., Black & Veatch, 4706 Broadway, Kansas City, Mo. (Oct. '56) *PD*

Vaughn, J. D., Foreman, Water Works, 651—14th St., N.W., Atlanta, Ga. (Oct. '56) *D*

Vilaret, Manuel R., Prado 360, Havana, Cuba (Oct. '56)

Wade, Robert W.; *see* Jasper (Ind.) Utility Service Board

Ways, Harry C., San. Engr., Dalecarlia Filter Plant, Washington, D.C. (Apr. '56) *MPD*

Weber, Frank; *see* Federal Telephone & Radio Co.

White, William D., Mfer.'s Repr., Walker Butler Co., 270 Rockefeller Bldg., Cleveland, Ohio (Oct. '56) *MRPD*

Whitty, Richard V., Jr., Sales Engr., Hagan Corp., 323—4th Ave., Pittsburgh 22, Pa. (Oct. '56) *PD*

Wiggins, Charles Dudley, Sanitation Foreman, Post Engrs., Service Co., 8362 Army Unit, APO 728, Seattle, Wash. (Oct. '56) *MP*

Williams, David L., Sales Engr., Rockwell Mfg. Co., 122 S. Michigan Ave., Chicago 3, Ill. (Oct. '56) *D*

EMGAMY Honor Roll

Listed below are the AWWA members who have contributed to "Every-Member-Get-A-Member Year" by getting members for the Sections shown, in the period Sep. 1–30. Numbers in parentheses indicate more than one member enrolled.

Alabama-Mississippi
Gilmore, W. H. (3)
Ham, J. E.

California
Aultman, W. W.
Bogs, G. J.
Brown, W. C.
Flor, L. L.
Hefty, M. R.
Luthin, J. C.
Peterson, C. J.
Robinson, J. W.
Streicher, Lee
Weight, W. O.
Wilfong, S. A.

Canadian
Berry, A. E.

Chesapeake
Jackson, N. E.
Taylor, W. H.

Florida
Snow, B. F.

Illinois
Trail, J. H., Jr.

Indiana
Becker, R. J.
Canham, C. H.
Foreman, J. D.
Gordon, Jack (6)
Griswold, H. S. (2)
Keith, H. L.
Moore, L. S.
Plautz, A. H.
Shillinger, W. D.

Iowa
Stookey, Robert

Kentucky-Tennessee
Eagwell, C. H.
Finney, J. W., Jr.
Olsen, Russ
Reynolds, G. R. (2)

Michigan
Fender, G. C.
Haase, Louis (2)
Hansen, R. E. (2)
Richardson, J. C.
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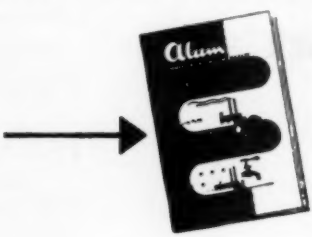
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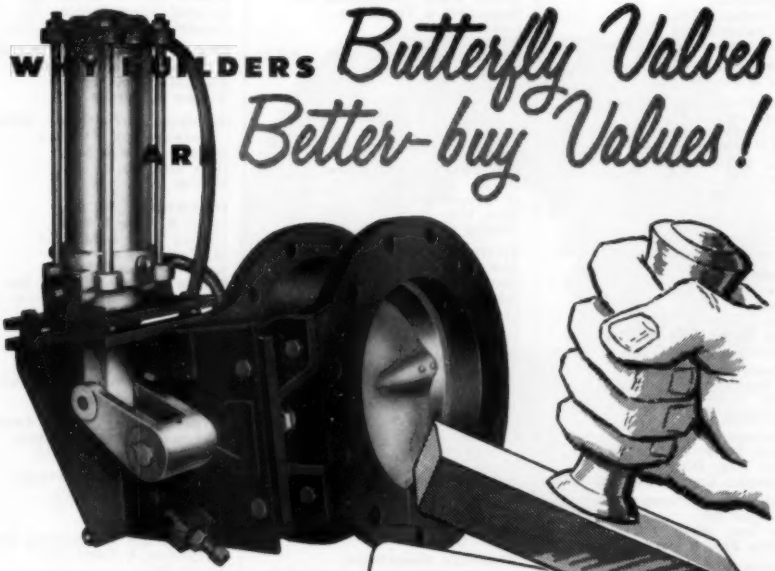
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from "Report on the Effect of Iron on High-Capacity Zeolite" *by* Edgar G. Will, Page 739, Journal AWWA—June, 1956.

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Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
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A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
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Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Shower Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Shower Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Henry Pratt Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

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Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
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Water Testing Apparatus:
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Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens:
Johnson, Edward E., Inc.

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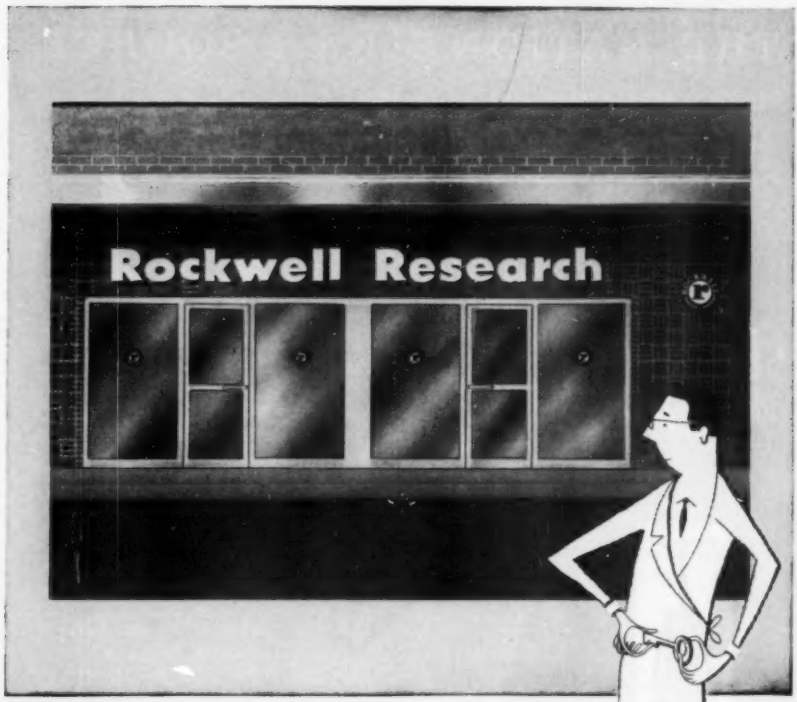
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